THE ZYGNEMATACEAE

HAY AND ED MOUL

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(FRESH-WATER CONJUGATE ALGAE)

With Keys
for the Identification of Genera and Species
and
Seven Hundred Eighty-Nine Illustrations

By

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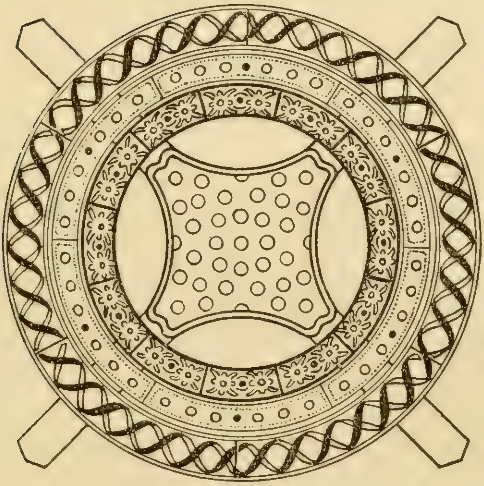
To the Graduate Students
who discovered many new species and
extended the known range of many other
Zygnemataceae



INTRODUCTION

The absence of a modern general key with detailed descriptions of the species belonging to the Zygnemataceae has greatly retarded the study of this family. This volume, it is hoped, will furnish a better manual for the identification of the genera and species than has been previously available. It seems self-evident that any studies of life histories, seasonal and cyclic abundance, and geographic distribution must be based on the accurate naming of the species considered. In addition to the literature about the Zygnemataceae, the present descriptions are based on data and specimens accumulated over a period of thirty-five years.

My interest in the group was originally stimulated by Mr. Frank S. Collins, who sent me many specimens he had collected, or received by exchange. These specimens were soon augmented by exsiccatae from Professors Borge, Nordstedt, Farlow, and Thaxter. These included numerous type specimens from many sources, and made possible the revision of earlier descriptions and the devising of new keys for the separation of species. Meanwhile, thousands of collections became available for study through the collecting activities of associates, graduate students, and myself throughout the eastern half of the United States, and from Ontario to Cape Breton Island. From Finland, Latvia, South Africa, Central and South America, Puerto Rico, China, India, Japan, and the Philippine Islands, several hundred additional collections have been received from correspondents. During the most active period of the study of these collections, I had the assistance of Professors L. H. Tiffany and C. E. Taft, who checked literally scores of the determinations and verified numerous descriptions of new species. To them I am most grateful for their help, and for the feeling of satisfaction that the new descriptions, particularly of spore walls, have been verified by at least one other pair of eyes.

Whether one accepts all of the genera, or all of the species, as valid or not, they seemed to differ in enough particulars to warrant their separation at the time they were studied. Some of the species described during the early history of the group have been

omitted because of faulty descriptions. Also some recent descriptions have had to be passed over because they lacked important details, or because of discrepancies between figures and descriptions. I have no doubt that some of these species are valid, and if additional information could have been obtained, they would have been included. No attempt has been made to guess at the synonomy of all previously published species names. Such guesses can be found in the *Sylloge Algarum* by G. B. de Toni (1889), in the *Süsswasserflora Mitteleuropa,* 9 (1932), and in *Rabenhorst's Kryptogamenflora,* 13 (1941–44), abt. II. In the absence of complete descriptions, or of the actual specimens, such conjectures seem gratuitous. Synonyms that are the result of different concepts of generic or specific limits are usually given. A few species with incomplete descriptions, but with conspicuous structures that distinguish them from other somewhat similar species, have been retained.

Among the many friends and students who have contributed collections containing Zygnemataceae, I am particularly indebted to Alma Ackley, Wayne University; Charles C. Adams, New York State Museum; D. B. Anderson, Agricultural and Technical College of North Carolina; the late W. M. Barrows, The Ohio State University; Glenn W. Blaydes, The Ohio State University; E. T. Bodenberg, Wittenberg College; Harold C. Bold, Vanderbilt University; Helen B. Bromley, Stamford, Connecticut; Charles Bullard, late of Harvard University; C. Cedercreutz, Helsingfors, Finland; Glenn Couch, University of Oklahoma; Francis Drouet, Chicago Natural History Museum; R. B. Gordon, Westchester Teachers College; Lawrence Hicks, Columbus, Ohio; Elwyn Hughes, University of Oklahoma; G. J. Ikenberry, Oklahoma Agricultural and Mechanical College; Chin-Chih Jao, Chungking, China; Minnie M. Johnson, Stephens College; Ivey Lewis, University of Virginia; Liang Ching Li, Fan Memorial Institute of Peiping, China; Floyd A. McClure, Lingnan University; B. B. McInteer, University of Kentucky; George Nichols, late of Yale University; Claude E. O'Neal, Ohio Wesleyan University; Gerald Prescott, Michigan State College; M. S. Randhawa, Fyzabad, India; H. C. Sampson, The Ohio State University; H. Skuja, Uppsala University, Sweden; Ben H. Smith, Indiana State Teachers College; G. M. Smith, Stanford University; Edith L. Stephens, University of South Africa; E. L. Stover, Eastern

Illinois State Teachers College; Clarence E. Taft, The Ohio State University; Hiram Thut, Eastern Illinois State Teachers College; L. H. Tiffany, Northwestern University; and Larry Whitford, Agricultural and Technical College of North Carolina.

In checking the descriptions, keys, and references, I had the assistance of Mrs. Maynard Hale and Mrs. Robert Sigafoos. They added much to the accuracy of the text, the indexing, and the uniformity of the references. Professor John L. Blum of Canisius College, Buffalo, copied or adapted many of the published figures and added many new figures and details of spore walls. Without his help the publication would have been greatly delayed. I am grateful to each of these associates for their contributions to the usableness of the keys.

The Graduate School of The Ohio State University has aided in the editorial work, and in the preparation of the figures and plates. It is a pleasure to acknowledge this financial assistance.

No attempt has been made to draw the figures to a certain scale of magnification. Since the descriptions give the dimensions, the principal value of the illustrations is the form of the various structures associated with reproduction and the details of spore-wall markings. The 789 figures illustrate 534 species, and all of the known types of gametangia and spores.

E. N. T.

Columbus, Ohio
1950

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THE
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CHAPTER ONE

GENERAL TAXONOMIC CHARACTERISTICS

The Order ZYGNEMATALES G. M. Smith 1933

The plants belonging to this order of the Chlorophyta differ from all other green algae in the absence of free swimming flagellated gametes and spores; sexual reproduction is consummated by amoeboid gametes through, or within, a tube, pectic sheath, or an enveloping pectic mass.

The plants consist of single cells, of loose cell aggregates within a pectic gel, or of unbranched or very sparsely branched, and usually undifferentiated, filaments. The cell walls have an outer pectic layer and an inner cellulose layer. The spore walls consist of at least three layers, the inner and outer of which are of cellulose, and the median wall of cellulose with varying amounts of chitinous deposits. The median wall may be colored yellow, brown, or blue.

The chromatophores may consist of axial or parietal plates, or spirally arranged parietal ribbonlike structures, or of two axial stellate bodies often highly diversified among the desmids.

The zygospores have a dormant period during which there is a fusion of the gametic nuclei followed by a reduction division. At the time of germination the four resulting nuclei may each become the center of a new cell, or two or three of the nuclei may disintegrate and only two or one sporelings emerge from the spore wall.

The Zygnematales are naturally divided into three families which have, briefly, the following characteristics:

FAMILY I. ZYGNEMATACEAE

These are filamentous plants, usually unbranched, and have cylindric cells. The walls of the vegetative cells are unsegmented and without pores. The chromatophores are either axial more or less stellate, ribbonlike or platelike bodies; or are parietal platelike or spirally arranged ribbonlike bodies. Conjugation of

gametes is by means of a tube between the gametangia, or sometimes by a mere opening between the adherent gametangia. The zygospores are formed either in the tube or within one of the gametangia.

FAMILY 2. MESOTAENIACEAE

Vegetative cells are solitary, cylindric or spindle-shaped, or sometimes loosely united into filaments within an amorphous pectic gel or pectic sheath, and without wall pores. Chromatophores are stellate, platelike, or ribbonlike and spirally arranged. Conjugation of gametes occurs through tubes of cellulose, or within a pectic gel.

FAMILY 3. DESMIDIACEAE

Vegetative cells are solitary, or sometimes are united into simple filaments. Vegetative cells have highly diversified and sometimes bizarre forms, but all have transversely segmented walls and wall pores. In most genera the cells have a median constriction or isthmus between the two nearly symmetrical halves. There may be one or several chromatophores in each semicell with a nucleus in the isthmus. During cell division, after the nucleus divides, the isthmus elongates and the two semicells are separated by a median wall. On both sides of this wall new semicells develop from the isthmus. Conjugation is by gametes that emerge from their respective cell walls and unite within an amorphous pectic sheath or in a conjugating tube. (For further details see G. W. Prescott, "Desmids," *Botanical Review,* **14** [1948], pp. 644–76.)

The Family ZYGNEMATACEAE Smith 1933

The species belonging to the Zygnemataceae are probably more numerous, and are more generally distributed over the earth than those of any other family of filamentous green algae. The tangled green masses of algae floating on ponds, ditches, and slow streams anywhere are sure to contain representatives of this group.

All the species have cylindric cells during the period of vegetative growth. During the reproductive period, however, the cell walls of some species grow and change their size and form in a most astonishing manner. In some species the gametangia alone are affected. The receptive gametangia in particular may become distended on all sides, on the conjugating side only, or only on

the opposite side. The bulges may be rounded, or cylindric with shoulders at both ends, or spindle-shaped. In any event the resulting forms of the expanding cell walls are remarkably uniform in a given species. In other species many of the nonreproducing cells enlarge and become distended or even bullate. These changes in cell form are definitely the result of hereditary factors.

In some environments one may also find vegetative filaments composed of variously rounded or distorted cells, even with rhizoidlike outgrowths, in extreme instances. These collections, in my experience, have always been gathered from ponds with warm water and low oxygen pressure. Since these effects were noted on several of the species present, the causes are probably environmental.

The following key to the genera is based primarily on the characteristics of the chromatophores, and secondarily on the changes that take place in the reproductive cells during spore formation.

In the subsequent keys to the species grouped under each genus stress is laid on the characteristics of the spores. Consequently one must be quite clear about the nature of these several kinds of reproductive structures.

The simplest, most universally present, and probably the most primitive type of propagating cell is the *akinete* (Pl. I, Figs. 1–3). This is usually just a vegetative cell, the walls of which have been thickened by additional layers of cellulose, or cellulose and pectose. These cells survive long periods of drought, high and low temperatures, as well as the effects of these factors on the concentration of solutes in their immediate environments. Akinetes germinate readily and initiate new filaments. Only one species *(Zygnema sterile)* has been found to reproduce by this method alone. There are probably many others but they are not so easy to identify as this one, which happens to be the largest species of *Zygnema* in the Ohio valley.

There is a prevalent notion that akinetes are formed when conditions are unfavorable. It has been our experience that they develop both when conditions seem most favorable and when least favorable. In cultures, they appear both at high temperatures and low temperatures. The causes for the initiation of akinetes are best stated as unknown.

At high altitudes and latitudes the species of Zygnemataceae

are common but are rarely found producing spores. These species cannot be identified because the modern species keys are necessarily built around spore characteristics. Akinetes are common in collections from these short-season regions, and by means of them survival and propagation of many species take place. There is no good reason to assume that all these species would produce spores in other environments. It is far more likely that some of these species are wholly vegetative, or akinetic.

There are other species in several of the genera that also reproduce by *aplanospores.* These are slightly more specialized than akinetes. Their forerunners are vegetative cells, the protoplasts of which have contracted more or less, and in which new walls of cellulose, with or without chitinous deposits, have developed. The spore walls may be colorless and smooth, or variously colored, sculptured, and ornamented. The criteria used to distinguish aplanospores in Zygnematales are precisely the same as those used to designate aplanospores among the Ulotrichales (Pl. I, Figs. 4–7).

Of the species here described, thirty-seven reproduce regularly by aplanospores, and zygospores have been found in the same filaments only rarely. Scattered aplanospores also occur along with zygospores in seventy-six additional species which belong to 7 genera. Moreover, only a few algologists have been interested in looking for aplanospores or the list probably would be larger. When found, aplanospores have often been written off as algal errors, since most authors state definitely that none of the species of Zygnemataceae "forms asexual reproductive bodies" (Smith 1933), or suspect that they are the result of lateral conjugation (Czurda 1932). The "lateral conjugation" theory rests on statements by Petit (1880), W. & G. S. West (1902), with a figure of a disintegrating chromatophore, and figures by Czurda (1931), without nuclei and also with disintegrating chromatophores. The latter series of figures seems to prove only that this unnamed species of *Mougeotia* may have under experimental conditions lateral conjugation, as have 6 other species in nature. It has little or no significance in proving that the numerous aplanospores occurring in nature which have been carefully studied during their entire development are zygospores.

Zygospores result from the union of gametes that are more or less similar in appearance, but physiologically different. The maturation and union of gametes always take place within the

walls formed by the conjugating tube and the two gametangia. This conjugation apparatus is relatively persistent and the zygospore remains in the enclosure for days or weeks after its own walls are mature. Zygospores at first have two nuclei and either one set of chromatophores *(Spirogyra)* derived from the receptive gametangium, or two sets *(Zygnema* and *Mougeotia)* derived from both gametangia, one of which disintegrates later. After the union of the nuclei, reduction division occurs and four nuclei result. Of these, three disintegrate and the remaining one becomes the nucleus of the basal cell of the sporeling on germination.

Only when one contemplates the many successive steps in conjugation from the development of papillae and adhesion of the gametangia onward to the maturation of the spore walls and protoplast, does he realize how very complicated are the chemical, physical, and biological processes that are integrated in zygospore development (Pl. I, Figs. 3, 8, 9, and 10).

*Parthenospore*s may be formed when the normal union of one gamete with another fails to occur either by absence of an opposite gamete, or by sudden changes in environmental conditions. In some collections gametes are numerous; in others, rare. Parthenospores can usually be distinguished from aplanospores by their position in the gametangial cells and their relation to adjacent zygospores. It is customary to say that "they resemble the zygospores of the same species but are smaller." Akinetes, aplanospores, zygospores, and parthenospores have all been seen germinating by numerous students. New filaments grow from any of these forms.

The taxonomy of the Zygnemataceae has been centered on the conjugation apparatus: its development, forms, and zygospores. The evolutionary history of reproduction in the group, however, must have begun with propagation and survival by akinetes. These are frequently seen in other families of the Chlorophyta. The development of aplanospores must have been a next step in evolution. This is not a large step either, since it implies merely the contraction of the protoplast and the growth of a spore wall. This type of spore also occurs in many other families of the Chlorophyta.

When aplanosporangia became differentiated chemically and hormones with plus and minus properties were released which brought about local growth of cell walls followed by adhesions

between cells, the first step in conjugation had been taken. Adhesion without conjugation occurs in several species of *Mougeotia.*

Conjugation is attained when the double wall formed by adhesion is dissolved locally by enzyme action. The two protoplasts or gametes are then in direct contact and the conjugating apparatus is established.

Obviously the primitive akinetic or aplanosporic species lacked the most characteristic feature of present-day Zygnemataceae until the regular union of gametes through openings between adjacent gametangia became the most prevalent mode of reproduction.

From this point of view parthenospores are protoplasts which started up the gametic pathway but had their development terminated at the level of aplanospores. Since they contain the same factors for wall color and patterns, the walls of parthenospores resemble those of the *aplanospores* of the same species. Since zygospores also contain these same factors for wall characteristics, one would hardly expect them to have other wall structures. One would anticipate larger sizes and other forms, since they are the product of two protoplasts. From this point of view, one should say that the walls of zygospores resemble those of the aplanospores rather than the reverse. These surmises concerning the order of development of the several reproductive structures seem far more plausible than the traditional statements and implications that the ancestral form of reproduction was by zygospores, and that the parthenospores and aplanospores have eventuated from the conjugation apparatus by the loss of factors, enzymes, and hormones.

Of the 534 species of Zygnemataceae here described 1 reproduces only by akinetes, 38 by aplanospores, 494 by zygospores, and 1 has been found only in a vegetative condition. Of the 494 zygosporic species, scalariform conjugation occurs in 400 species; 72 species have both lateral and scalariform conjugation; and 22 species usually conjugate only laterally. Probably all the species propagate by akinetes, and 77 of the zygosporic species also reproduce by aplanospores. Most spores are colorless, yellow, or brown. Blue spore walls have been found only in the genera: *Zygnema* (30 species), *Zynemopsis* (1 species), *Zygogonium* (2 species), and *Mougeotia* (8 species).

In this family only the zygospores may be hybrid in character following conjugation between different species. The filaments that develop from hybrid zygospores are haploid, meiotic, or

gametic segregates. In the few instances in which such progeny have been studied, individual filaments inherit the factor for cell diameters, forms of receptive gametangia, zygospore size, form, and wall markings independently. They are expressed through the cytoplasm of the female gametes. So long as these segregates reproduce by cell division, by akinetes, by aplanospores, and by conjugation between cells of the same haploid filament, the gene complex of the progeny is identical and the filaments are uniform. Doubtless many of the "species" that are collected and named are taxonomic units, or clones, that have originated in this way. Other species seem to have originated by polyploidy and by mutation, but the evidence for this statement is purely circumstantial.

The bases for the separation of the genera are shown in the following key. Three genera *(Hallasia, Pleurodiscus,* and *Entransia)* are tentatively and purposely defined to emphasize the need for further study of the development and reproduction of these species. All the forms described in this key are designated as "species." Many variations have been seen in the collections studied but until more is known about hybrid segregates, isolated clones, and the effects of the various environmental factors, it seems unprofitable to assign "variety" and "form" names to every variant. Many alleged "varieties" are not even closely related to the species to which they have been assigned.

Key to the Genera of ZYGNEMATACEAE

I. Vegetative cells usually with 2 axile chromatophores, which are round, radially branched, pillow-shaped, or disclike, with nucleus contained in the cytoplasmic bridge between them

1. Chromatophores usually a pair of axile stellate or globose radially symmetric bodies, each with a central pyrenoid

a) Zygospores compressed-globose or ovoid in the tubes or in one of the gametangia; aplanospores cylindric-ovoid occupying all or most of the cell; gametangia not filled with a dense refractive colloid after conjugation, and without cytoplasmic residues .... 1. *Zygnema*

b) Zygospores quadrangular-ovoid, or round pillow-shaped, formed in the extremely wide but shallow conjugating tubes; aplanospores ellipsoid or asymmetrically ovoid; successive layers of cellulose and pectic colloids added inside the gametangial walls during conjugation; similar changes occur in

sporiferous cells during aplanospore formation; no cytoplasmic residues .... 2. *Zygnemopsis*

c) Zygospores unknown; 2–7 chromatophores in the cells; aplanospores ellipsoid, on germination 1–3 sporelings develop from each..................... 3. *Hallasia*

2. Chromatophores a pair of ovoid bodies with, or without, irregular processes, each containing a pyrenoid; zygospores in sporangia of 2 cuplike parts with a suture between; aplanospores and akinetes the usual method of reproduction; gametangia and aplanosporangia contain cytoplasmic residues after conjugation and spore formation.............. 4. *Zygogonium*

3. Chromatophores a pair of disc-shaped bodies each with a central pyrenoid; sporangium wall of 2 cups with an equatorial belt between them, otherwise similar to *Zygogonium*
5. *Pleurodiscus*

II. Vegetative cells, with single axile, platelike chromatophores without pyrenoids; nucleus attached laterally near middle of the cell
6. *Mougeotiopsis*

III. Vegetative cells with 1, rarely 2, axile, flat ribbonlike or platelike chromatophores, with several or many pyrenoids; nucleus attached laterally or between the chromatophores when 2 are present

1. Gametangia similar to the vegetative cells before the beginning of conjugation

a) During conjugation successive layers of pectic and cellulose colloids are added to the inside of the gametangial walls, filling the lumen; walls of sporangia similarly modified during spore formation............ 7. *Debarya*

b) During conjugation as the gametes contract and move toward the conjugating tubes granular cytoplasmic residues are left in the gametangia...... 8. *Mougeotia*

2. Gametangia are short specialized cells cut off near the ends of long vegetative cells............... 9. *Temnogametum*

IV. Vegetative cells with 2 parallel flat chromatophores on opposite sides of the cell, each containing several pyrenoids; nucleus central in a cytoplasmic pillar between the flat sides of the 2 chromatophores; conjugation between reflexed gametangia
10. *Sirocladium*

V. Vegetative cells with 1 or 2 broad parietal chromatophores on one side of the cell, each with several pyrenoids, and laciniate lateral margins; in young cells the nucleus is near the middle of the single chromatophore, in mature cells in bridge between the 2 chromatophores; reproduction unknown..... 11. *Entransia*

VI. Vegetative cells with 1 to 16 parietal, more or less spirally arranged ribbonlike chromatophores, each with several or many pyrenoids arranged in a single median line; nuclei centrally located and supported by cytoplasmic strands; zygospores ellipsoid, ovoid, or lenticular, always formed in one of the gametangia

1. With conjugating tubes formed by one or both gametangia before conjugation; outer layer of vegetative cell walls of pectic compounds, which usually disappears during conjugation 12. *Spirogyra*

2. Without conjugating tubes, conjugation directly through an opening where the reflexed gametangia are in contact; this area of contact becomes encircled by a ring of pectic compound; vegetative cells without a pectic sheath, chromatophores only slightly curved.................... 13. *Sirogonium*

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TABLE I

Summary of the Observed
Usual Methods of Reproduction among the Zygnemataceae

	Akinetes	Aplanospores	Zygospores Conjugation			Total Number of Species
			Scalariform	Scalariform and Lateral	Lateral	
Zygnema	1	12	70	9	3	95
Zygnemopsis	0	5	19	0	0	24
Hallasia	0	1	0	0	0	1
Zygogonium	0	5	3	5	1	14
Pleurodiscus	0	0	1	0	0	1
Mougeotiopsis	0	0	1	0	0	1
Debarya	0	0	6	0	0	6
Mougeotia	0	7	86	4	2	99
Temnogametum ...	0	0	1	3	0	4
Sirocladium	0	0	1	0	0	1
Entransia	..	..	..	..	..	..
Spirogyra	0	8	200	51	16	275
Sirogonium	0	0	12	0	0	12
Totals	1	38	400	72	22	533
			494			

Of the 494 species that usually reproduce by zygospores, 77 sometimes also reproduce by aplanospores. These species are distributed as follows: *Spirogyra,* 25; *Mougeotia,* 25; *Zygnema,* 16; *Zygnemopsis,* 5; *Zygogonium,* 2; *Debarya,* 1; *Temnogametum,* 2; and *Sirocladium,* 1.

CHAPTER TWO

THE GENUS ZYGNEMA C. A. AGARDH 1824

The plants classified as species of *Zygnema* consist of unbranched filaments of short cylindric cells usually covered by a pectose sheath. To the field collector they are less slippery than the *Spirogyras* but more slippery than the *Mougeotias*. There are exceptions, of course, because the sheaths vary in thickness from those which are barely visible under the microscope to those which are thicker than the cells themselves. In regions of low temperature and alkaline water, the sheaths are denser and highly stable. Similar sheaths are found on filaments living on wet shaded soil on pond margins. The thicker sheaths often have visible structural lines at right angles to the filaments.

Zygnemas live as annuals, and may complete their life cycle in a few weeks and then disappear. They are most abundant and more frequently found reproducing in temporary ponds and ditches. In permanent ponds one may find vegetative filaments throughout the year. This is not to be construed as evidence that individual plants are perennial. It is far more probable that the germination of spores and akinetes occurs throughout the year. In cold temperate regions the most abundant germination starts in autumn and winter, and culminates in early spring. As ponds become shaded by the growth of marginal shrubs and trees, reproduction decreases and finally ceases entirely, but the *Zygnemas* are perpetuated for a subsequent period of years by the overwintering of akinetes and fragments of filaments. They survive cold and dry periods in the ooze and silt of the pond bottom. During the drought period between 1930 and 1935 a small pond near Columbus, Ohio, was dry for three and a half years. When the rains finally restored the pond, filaments of *Zygnema sterile* became abundant within three weeks. This species reproduces by akinetes only.

Zygnemas have been collected on all the continents from sea level to alpine summits, and from the torrid to the frigid zones.

In higher latitudes and altitudes the species are not well known because they rarely have been found with zygospores.

In warm regions it is not improbable that some species are perennial; that is, some of the filaments form spores and die, while others merely break into segments which continue vegetative growth. In well-aerated running water the *Zygnemas* are rarely found fruiting, but in the shallow pools adjoining such streams one can usually collect the same species in a fruiting condition.

The average length of the filaments of *Zygnemas* is a few inches, much shorter than that of the *Spirogyras*. Apparently before the filaments become very long the pectic sheath breaks and the cells separate. Cell diameters vary from 8 to 58μ, but more than half the species have cell diameters between 20 and 30μ.

Usually there are two axial chromatophores in each cell with the nucleus contained in the cytoplasmic bridge connecting them. Each chromatophore consists of a round body, with irregular short branches radiating in all planes, containing a conspicuous central pyrenoid. As a result of food accumulation the chromatophores may become merely two large globose bodies, or may completely fill the lumen of the cell.

On rare occasions one may find filaments in which each cell has two axial chromatophores on either side of the nucleus. In three collections that I have examined there were four chromatophores in the cells of some filaments arranged in the form of an X with the nucleus in the center.

Sexual reproduction occurs in 82 of the 95 described species. Twelve others reproduce by aplanospores, and 1 by akinetes only. Of the described species reproducing by zygospores 37 are isogamous, with spores in the conjugating tubes; and 45 are anisogamous, with spores in one of the gametangia. Of the 95 species, 70 have scalariform conjugation, 9 both scalariform and lateral conjugation, and 3 lateral conjugation; no conjugation has been observed in the remaining species. Thirty species have blue median spore walls when mature. During development these walls change from colorless to yellow, to brown, to blue. As not all spores mature at the same time, one may find all these stages in a collection. If some of the spores are blue, one may be sure that the other spores in the filament are immature.

Four chromatophores are usually visible in immature zygo-

spores, and in parthenospores and aplanospores only two. In general the zygospores are compressed-globose or ovoid. There is an equatorial suture often marked by a slight ridge or keel (carinate), and in some species there are two lesser ridges on either side of the suture and parallel with it. These may not be visible in fresh fully distended spores but they become evident in dried or plasmolyzed specimens. Usually, the polar, or flatter, sides of the spores lie in the plane of the tubes, but there are 6 species in which the plane of compression is at right angles to the axis of the tubes.

The most abundant and generally distributed of the brown-spored isogamous species is *Z. pectinatum,* of the blue-spored isogamous species, *Z. synadelphum.* Of the anisogamous brown-spored species *Z. stellinum* is both abundant and widely distributed; *Z. peliosporum* is its counterpart among the blue-spored species. As might be expected, all these species are highly variable in dimensions, and local varieties and forms are apparently common. It is not improbable that they have been the mutating forerunners of nearly related species found locally wherever the *Zygnemas* have been studied intensively.

There is no good evidence that the taxonomic characteristics of species are changed materially by environmental conditions. There are alterations in chromatophores, accumulated foods, and thickness of walls due to exposure on soil, restricted photosynthesis, low temperatures, and mineral deficiencies. Reproductive capacity may be decreased or increased by external conditions. The mode of reproduction by zygospores or aplanospores, and the placement of the zygospores in the tubes, or in one of the gametangia, are the results of hereditary rather than environmental factors. In any one species the position of the spores, whether in the tubes or in the gametangia, does not change from season to season (see Fritsch and Rich, *New Phytologist,* 26 [1927]). There are several species in which the spores occur in either the gametangia or the tubes—even in the same pair of conjugating filaments.

The identification of a species depends partly upon the dimensions of the vegetative cells. Vegetative cell diameters should be measured at the partition walls. Most important are the relative dimensions of the spores, their form, and the color and ornamentation of the several layers of the spore walls. Obviously only

specimens with mature spore walls can be named with any degree of satisfaction. Not infrequently the ornamentation can be determined only by crushing and separating the several layers of the spore wall. In the matter of dimensions, the student should remember that every species is a complex of clones with cells of slightly different sizes and proportions. These may be in part smaller or larger than the dimensions given in the key. The dimensions given in the descriptions of species are either those of the original collection, or the dimensions as they may have been modified by the study of subsequent collections. How great a departure from the original is necessary to warrant the segregation of a new species cannot be determined by any simple rule. Study and restudy of many collections will show that some species are only narrowly variable, while others vary within wide limits. These remarks are equally applicable to the species of other genera of the Zygnemataceae.

In the descriptions of species the characteristics of the outer spore wall are usually omitted since there are only a few species in which they are not thin, smooth, colorless, and transparent. The median spore wall may be variously colored and ornamented. I have tried to distinguish among punctate, scrobiculate, and pitted according to the size of the pits, and in many instances have been able to give the diameters of the pits and the distances between them in microns. Errors sometimes occur in descriptions and figures where contraction ridges and irregular folds are mistaken for ornamentation. These may be due to contraction of the spore contents either by drying or by plasmolysis, and may be recognized readily by applying a dilute solution of potassium hydroxide. Real structural patterns are enlarged and made more distinct by this treatment, while contraction ridges disappear. In studying dried specimens it is well first to wet them with water on the slide and then to apply a drop of lactic acid, and after that to heat the slide until the acid begins to boil. This treatment will remove calcium carbonate and clarify both the walls and cell contents of most species. Some of the older species were described as having smooth median spore walls, although recent study of the type specimens has shown them to be punctate. This circumstance is probably explained by the poor resolving power of the microscope lenses of the last century as compared with those available today.

It may be of historic interest to know that certain species of *Zygnema* have been classified previously in the genera: *Globulina* Link 1820; *Tendaridea* Bory 1822–31; *Stellulina* Link 1833; *Tyndaridea* Hassall 1841; *Zygogonium* Kützing 1843; and *Thwaitesia* Montagne 1845. More recently Czurda (1932) has included among the *Zygnemas* certain species which are here classified in the genera: *Zygogonium, Zygnemopsis, Hallasia,* and *Pleurodiscus.*

Key to Species of ZYGNEMA

1. With aplanospores, zygospores infrequent or absent.......... 53
1. With zygospores, sometimes aplanospores also................ 2
    2. Zygospores wholly or largely in the conjugating tubes.... 3
    2. Zygospores usually in one of the gametangia............. 26
3. Median spore wall colorless, yellow, or brown when mature.. 4
3. Median spore wall blue when mature...................... 17
    4. Zygospores globose to ovoid........................... 5
    4. Zygospores compressed, at right angles to the tubes....... 22
5. Diameter vegetative cells less than 20 μ..................... 6
5. Diameter vegetative cells usually 20 to 30 μ.................. 8
5. Diameter vegetative cells usually 30 to 40 μ.................. 15
5. Diameter vegetative cells more than 40 μ.................... 16
    6. Vegetative cells 8–12 μ in diameter. 1. *Z. oveidanum*
    6. Vegetative cells 12–16 μ in diameter.................... 7
    6. Vegetative cells 16–20 μ in diameter, spores, scrobiculate............... 4. *Z. decussatum*
    6. Vegetative cells 16–20 μ in diameter, spores, smooth..................... 91. *Z. gangeticum*
7. Median spore wall scrobiculate....... 2. *Z. carterae*
7. Median spore wall smooth............ 3. *Z. laevisporum*
    8. Median spore wall a single layer........................ 9
    8. Median spore wall of 2 layers........................... 14
9. Zygospore median wall smooth....... 23. *Z. czurdae*
9. Zygospore median wall scrobiculate, pits less than 4 μ......... 10
9. Zygospore median wall scrobiculate, pits more than 4 μ....... 13
9. Zygospore median wall reticulate..... 14. *Z. pseudopectinatum*
    10. Diameter cells 20–22 μ, lateral conjugation through end walls....... 5. *Z. himalayense*
    10. Diameter cells 20–30 μ, conjugating tubes of usual form... 11
11. Spores usually less than 40 μ in diameter.................... 12

11. Spores usually more than 40μ in diameter .... 7. *Z. skujae*
12. Spores $24–33\mu$, scrobiculate, diameter pits less than 2μ.............. 6. *Z. conspicuum*
12. Spores $33–40\mu$, scrobiculate, diameter pits $3–4\mu$.................... 8. *Z. lawtonianum*
12. Spores $38–42\mu$, punctate and ridged 10. *Z. chungii*
12. Spores $36–45\mu$, scrobiculate, diameter pits 2μ...................... 13. *Z. adpectinatum*
13. Diameter median spore wall pits $5–8\mu$. 11. *Z. sinense*
13. Diameter median spore wall pits 4μ... 12. *Z. globosum*
14. Outer layer wrinkled, inner verrucose .... 9. *Z. verrucosum*
14. Outer layer scrobiculate, inner verrucose .... 16. *Z. laetevirens*
14. Outer layer pitted, inner verrucose. 15. *Z. areolatum*
15. Median spore wall single, pits $2–3\mu$ in diameter .... 17. *Z. pectinatum*
15. Median spore wall single, pits $3–4\mu$ in diameter .... 18. *Z. excrassum*
15. Median spore wall double, outer verrucose .... 9. *Z. verrucosum*
16. With median spore wall single.... 19. *Z. neopectinatum*
16. With median spore wall double... 20. *Z. giganteum*
17. Diameter vegetative cells 16μ or less.. 21. *Z. gedeanum*
17. Diameter vegetative cells $17–27\mu$............................ 18
17. Diameter vegetative cells more than 27μ.................... 21
18. Median wall smooth.................................... 19
18. Median wall not smooth................................ 20
19. Median spore wall dark blue, diameter $34–40\mu$ .... 22. *Z. cyanosporum*
19. Median spore wall light blue, diameter $30–40\mu$ .... 23. *Z. czurdae*
20. Diameter vegetative cells $16–18\mu$, spores compressed .... 35. *Z. carinatum*
20. Diameter vegetative cells $17–24\mu$.. 24. *Z. synadelphum*
20. Diameter vegetative cells $24–26\mu$, diameter spore $32–35\mu$ .... 26. *Z. coeruleum*
20. Diameter vegetative cells $23–27\mu$, diameter spore $36–42\mu$ .... 27. *Z. gorakhporense*
20. Diameter vegetative cells $18–24\mu$, forming mats on soil............. 25. *Z. terrestre*

21. Vegetative cell diameter 27–30 μ...... 28. *Z. majus*
21. Vegetative cell diameter 32–38 μ...... 29. *Z. kiangsiense*
 22. Zygospores blue, carinate, and punctate .... 35. *Z. carinatum*
 22. Zygospores yellow to brown........................... 23
23. Diameter vegetative cells 14–20 μ........................ 24
23. Diameter vegetative cells 20 μ or more..................... 25
 24. Spores 15–25 μ x 25–35 μ, all walls smooth .... 30. *Z. ralfsii*
 24. Spores 28–32 μ x 36–40 μ, median wall punctate .... 31. *Z. micropunctatum*
25. Median spore wall smooth, brown.... 32. *Z. momoniense*
25. Median spore wall pitted, yellow-brown 33. *Z. circumcarinatum*
25. Median spore wall double, outer layer smooth, inner verrucose.......... 34. *Z. pawhuskae*

SPORES IN THE GAMETANGIA

 26. Median spore wall colorless, yellow, or brown............ 27
 26. Median spore wall blue................................ 45
27. Diameter vegetative cells less than 20 μ..................... 28
27. Diameter vegetative cells 20–30 μ.......................... 29
27. Diameter vegetative cells more than 30 μ.................... 40
 28. Vegetative cell diameter 9–12 μ, spore wall punctate .... 36. *Z. stagnale*
 28. Vegetative cell diameter 14–20 μ, spore wall punctate .... 37. *Z. subtile*
 28. Vegetative cell diameter 15–18 μ, spore wall punctate .... 38. *Z. cylindrospermum*
 28. Vegetative cell diameter 16–18 μ, spore wall with pits 3–4.5 μ .... 39. *Z. yunnanense*
29. Median spore wall smooth................................ 30
29. Median spore wall punctate to scrobiculate................. 31
29. Median spore wall verrucose............................. 39
 30. Diameter vegetative cells 20–24 μ.. 43. *Z. leiospermum*
 30. Diameter vegetative cells 26–30 μ.. 55. *Z. insigne*
31. Pits 2 μ or less in diameter................................ 32
31. Pits more than 2 μ in diameter............................ 33
 32. Diameter vegetative cells 22–29 μ, pits widely spaced................ 46. *Z. luteosporum*
 32. Diameter vegetative cells 23–26 μ, pits closely spaced................ 48. *Z. calosporum*

32. Diameter vegetative cells 24–30 μ, pits 2 diameters apart .... 53. *Z. subcruciatum*

33. Median wall pits 2–4 μ in diameter 34
33. Median wall pits more than 4 μ in diameter 36

34. Receptive gametangia nearly cylindric .... 49. *Z. vaucherii*
34. Receptive gametangia greatly enlarged .... 45. *Z. substellinum*
34. Receptive gametangia enlarged on conjugating side 35

35. Diameter vegetative cells 18–24 μ ...... 42. *Z. tenue*
35. Diameter vegetative cells 24–28 μ ...... 50. *Z. normani*
35. Diameter vegetative cells 28–38 μ ...... 59. *Z. stellinum*

36. Vegetative cells less than 24 μ in diameter 37
36. Vegetative cells more than 24 μ in diameter 38

37. Diameter median wall pits 4.5–6 μ .... 40. *Z. extenue*
37. Diameter median wall pits 7–9 μ ...... 44. *Z. hausmannii*

38. Receptive gametangia inflated inner side .... 51. *Z. insignisporum*
38. Receptive gametangia globosely inflated .... 54. *Z. germanicum*
38. Receptive gametangia nearly cylindric .... 56. *Z. fanicum*
38. Receptive gametangia enlarged ... 57. *Z. subfanicum*

39. Median spore wall verrucose .... 52. *Z. vaginatum*
39. Median spore wall with raised prominences .... 41. *Z. tholosporum*
39. Median spore wall double, inner layer verrucose .... 47. *Z. flavum*

40. Diameter vegetative cells 30–40 μ 41
40. Diameter vegetative cells 40–50 μ .. 65. *Z. neocruciatum*
40. Diameter vegetative cells 50–60 μ .. 66. *Z. crassiusculum*

41. Median spore wall scrobiculate or pitted 42
41. Median spore wall verrucose and wavy 62. *Z. bohemicum*
41. Median spore wall of 2 layers, inner reticulate-verrucose, outer thick, smooth .... 63. *Z. mirandum*

42. Median wall with pits less than 4 μ in diameter 43
42. Median wall with pits more than 4 μ in diameter 44

43. Spores usually globose, diameter pits 3–4 μ .... 59. *Z. stellinum*

43. Spores usually globose, diameter pits 1–2μ .... 60. *Z. cruciatum*
43. Spores cylindric-ovoid, diameter pits 1–2μ .... 61. *Z. cylindrosporum*

44. Diameter pits on median wall 2–6.5μ .... 92. *Z. kwangtungense*
44. Diameter pits on median wall 4–5μ 64. *Z. inconspicuum*
44. Diameter pits on median wall 7–12μ .... 58. *Z. transeauianum*

45. Receptive gametangia cylindric or slightly enlarged.......... 46
45. Receptive gametangia much enlarged or inflated............ 49

46. Diameter vegetative cells average less than 27μ.......... 47
46. Diameter vegetative cells average more than 27μ......... 48

47. Median spore wall with scattered punctations .... 90. *Z. mucigenum*
47. Median spore wall smooth........... 68. *Z. chalybeospermum*
47. Median spore wall punctate.......... 71. *Z. melanosporum*
47. Median spore wall scrobiculate and carinate .... 72. *Z. excompressum*

48. Median spore wall smooth........ 69. *Z. cyaneum*
48. Median spore wall densely punctate .... 74. *Z. azureum*
48. Median spore wall scrobiculate.... 79. *Z. catenatum*
48. Median spore wall pitted......... 77. *Z. ornatum*

49. Diameter vegetative cells less than 20μ...................... 50
49. Diameter vegetative cells 20–30μ............................. 51
49. Diameter vegetative cells more than 30μ.................... 52

50. Vegetative cells 14–17μ in diameter 67. *Z. atrocoeruleum*
50. Vegetative cells 18–24μ in diameter 70. *Z. collinsianum*

51. Median spore wall with pits 1–2μ in diameter .... 73. *Z. peliosporum*
51. Median spore wall with pits 3–4μ in diameter .... 75. *Z. carinthiacum*
51. Median spore wall with pits 4–5μ in diameter .... 70. *Z. collinsianum*
51. Median spore wall with pits 7–11μ in diameter .... 76. *Z. pawneanum*

52. Pits of median wall about 6μ in diameter .... 77. *Z. ornatum*
52. Pits of median wall about 3μ in diameter .... 78. *Z. excommune*

REPRODUCTION BY APLANOSPORES

53. Aplanospores blue.. 54
53. Aplanospores or akinetes yellow to brown.................. 55
54. Spores punctate with irregular elongate pits .... 87. *Z. borzae*
54. Spores scrobiculate, diameter vegetative cells 21–23 μ................ 80. *Z. frigidum*
54. Spores scrobiculate, diameter vegetative cells 33 μ.................... 85. *Z. hypnosporum*
54. Spores smooth .... 84. *Z. quadrangulatum*
55. Diameter vegetative cells less than 25 μ..................... 56
55. Diameter vegetative cells 26 to 36 μ......................... 57
55. Diameter vegetative cells greater than 36 μ................. 58
56. Vegetative cell diameter 15–18 μ, spores dolioform .... 94. *Z. mirificum*
56. Vegetative cell diameter 16–21 μ, spores ovoid .... 81. *Z. spontaneum*
56. Vegetative cell diameter 17–20 μ, spores cylindric .... 86. *Z. schwabei*
56. Vegetative cell diameter 20–22 μ, spores ellipsoid .... 93. *Z. ellipsoideum*
57. Median spore wall scrobiculate....... 82. *Z. cylindricum*
57. Median spore wall granulose......... 88. *Z. subcylindricum*
57. Median spore wall pitted............. 95. *Z. khannae*
58. Diameter vegetative cells 40–42 μ, spore cylindric .... 89. *Z. irregulare*
58. Diameter vegetative cells 44–54 μ, akinetes .... 83. *Z. sterile*

The following species have been found in some collections producing both zygospores and aplanospores: *Z. catenatum, Z. circumcarinatum, Z. collinsianum, Z. cruciatum, Z. excrassum, Z. fanicum, Z. giganteum, Z. insigne, Z. leiospermum, Z. neocruciatum, Z. pectinatum, Z. peliosporum, Z. stellinum, Z. terrestre,* and *Z. synadelphum*.

Descriptions of Species

1. Zygnema oveidanum Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 208, Pl. 17, Fig. 1.

Vegetative cells 8–12 μ x (32–)35–40(–68) μ; conjugation scalariform; zygospores formed in the conjugating tubes, ovoid to globose, 12–15 μ x 15–30 μ; median spore wall colorless to yellow, punctate; pits about 1 μ in diameter. (Pl. II, Fig. 3.)

United States: Florida, Oveida Springs, and Fort Myers; Louisiana, Alexandria.

2. Zygnema carterae Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 114. Carter. *Jour. Linn. Soc. of London Bot.* **46**, p. 62.

Vegetative cells 13–16μ in diameter; conjugation lateral or scalariform; zygospores formed in the conjugating tubes, globose, 30–35μ; median spore wall brown, scrobiculate.

New Caledonia (Carter).

3. Zygnema laevisporum Jao 1935. *Trans. Amer. Micros. Soc.* **54**, p. 56, Pl. 1, Figs. 7–8.

Vegetative cells 13–16μ x (48–)64–128μ; chromatophores usually 2, sometimes 3 or 4, occupying the middle of the cell; conjugation usually lateral, rarely scalariform; zygospores compressed-globose, formed in the conjugating tubes, 35–42μ x 32–35μ; median spore wall smooth and yellow-brown at maturity. (Pl. II, Figs. 5–6.)

United States: Massachusetts, Falmouth.

4. Zygnema decussatum (Vaucher) Agardh 1824. *Systema Algarum,* p. 78.

Vegetative cells 16–20μ x 35–100μ (2–5 diameters long); conjugation scalariform; zygospores formed in the conjugating tubes, globose to ovoid, 24–33μ x 26–36μ; median spore wall brown, finely scrobiculate. (Pl. II, Fig. 7.)

United States: Illinois; Indiana; Michigan; Massachusetts.

Widely reported from Europe; India; New Caledonia.

This form is not identical with *Zygnemopsis decussata* Transeau as transferred by Czurda. Both species have been found in the same pond. Their reproductive structures are quite dissimilar. (See Pl. IX, Figs. 12–15.)

5. Zygnema himalayense Randhawa 1940. *Proc. Indian Acad. Sci.* **12**, p. 129.

Vegetative cells 20–22μ x 60–120μ; conjugation lateral and scalariform. In lateral conjugation the gametes unite directly after solution of the wall between the gametangia. Zygospores formed in the conjugating tubes in scalariform conjugation; spores subglobose to ovoid, 36–40μ x 45–72μ; median spore wall scrobiculate, yellow-brown; pits 1–1.5μ in diameter, 3–4μ apart. (Pl. II, Fig. 4.)

India, Loharkhot, stream at an elevation of 5,750 feet in the Himalaya Mountains, September 15, 1939.

6. Zygnema conspicuum (Hassall) Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 208, Pl. 17, Fig. 2.

Vegetative cells 22–27μ x 50–90μ; conjugation scalariform; zygo-

spores formed in the conjugating tubes, globose to ovoid, 24–32μ x 26–33μ; median spore wall brown, scrobiculate; pits about 1.5–2.0μ in diameter and the same distance apart. (Pl. II, Fig. 8.)

United States: Illinois; Wisconsin; Oklahoma; Kentucky.

England; Germany; Austria; Belgium; Bulgaria; Russia.

7. Zygnema skujae Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 109. Skuja. *Acta Horti Bot. Univ. Latviensis.* 4, p. 40. 1929.

Vegetative cells 20–27μ x 40–100μ; conjugation scalariform; gametangia slightly bent; zygospores formed in the conjugating tubes, globose to ovoid, 40–55μ; median spore wall olive-brown, coarsely and thickly scrobiculate.

Latvia.

8. Zygnema lawtonianum Taft 1934. *Trans. Amer. Micros. Soc.* 53, p. 209, Pl. 17, Fig. 5.

Vegetative cells 23–27μ x 23–99μ; conjugation scalariform; zygospores formed in the conjugating tubes, globose to ovoid-globose with a distinct equatorial suture, 33–40μ x 33–46μ; outer spore wall united with the tube wall; median spore wall brown, coarsely scrobiculate; pits 3–4μ in diameter and about the same distance apart. Spores are cut off from the gametangia by a distinct cross wall. (Pl. II, Fig. 9.)

United States: Oklahoma, Medicine Park, April 29, 1932.

Burma (Skuja).

9. Zygnema verrucosum Jao 1935. *Sinensia.* 6, p. 566, Pl. 1, Figs. 3–4.

Vegetative cells 24–26μ x 29–48μ; conjugation scalariform; zygospores formed in the conjugating tubes, subglobose to ovoid, 32–37μ x 38–55μ; outer spore wall smooth, hyaline; median wall of 2 layers, of which the outer is yellow and irregularly wrinkled, the inner, yellow-brown and densely granulate to verrucose. (Pl. II, Figs. 10–11.)

China, Szechwan.

Differs from *Z. pawhuskae* Taft in the larger vegetative cells, the absence of a distinct suture on the spore, and the absence of compressed-ovoid spores.

10. Zygnema chungii Li 1934. *Trans. Amer. Micros. Soc.* 53, p. 213, Pl. 18, Fig. 15.

Vegetative cells 24–28μ x 58–72μ; conjugation scalariform; zygospores formed in the conjugating tubes, globose to ovoid, 38–42μ x 38–47μ; outer wall colorless, smooth; median spore wall yellow-brown,

thick, punctate, and marked by an irregular network of ridges; pits about 1 μ in diameter, 3–6 μ apart. (Pl. II, Fig. 12.)

China, Hupeh, Wuchang (H. H. Chung Coll.).

11. ZYGNEMA SINENSE Jao 1935. *Sinensia.* **6**, p. 567, Pl. 1, Fig. 5.

Vegetative cells 25–27 μ x 25–48 μ; conjugation scalariform; spores formed in the enlarged tubes, extending slightly into the gametangia; zygospores subglobose to ovoid, not compressed, 35–42 μ x 40–48 μ; median spore wall brown, pitted; pits 5–8 μ in diameter, 3–9 μ apart. (Pl. III, Fig. 1.)

China, Szechwan.

Differs from *Z. lawtonianum* Taft in larger zygospores, larger pits, and absence of distinct suture; from *Z. areolatum* Transeau in having a single median spore wall, larger pits, and smaller vegetative cells.

12. ZYGNEMA GLOBOSUM Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 109, Fig. 110.

Vegetative cells 26–28 μ x 70–95 μ; conjugation scalariform; zygospores formed in the conjugating tubes, globose or ovoid, 45–50 μ x 50–65 μ; median spore wall brown, thick, pitted; pits about 3 μ in diameter according to the figure. (Pl. III, Figs. 2–3.)

Bohemia; Central India.

13. ZYGNEMA ADPECTINATUM Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 209, Pl. 17, Fig. 6.

Vegetative cells 25–30 μ x 30–100 μ; conjugation scalariform; zygospores formed in the conjugating tubes, ovoid to globose, 36–40 μ x 40–50 μ; median spore wall yellow-brown, scrobiculate; pits 2 μ in diameter. (Pl. III, Fig. 4.)

United States: Illinois.

14. ZYGNEMA PSEUDOPECTINATUM Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 115, Fig. 117. Fritsch and Stephens. *Trans. Roy. Soc. S. Africa.* **9**, p. 53. 1921.

Vegetative cells 27–30 μ x 50–74 μ; conjugation scalariform and lateral; zygospores formed in the conjugating tubes, globose to ovoid, 33–36 μ x 40 μ; median spore wall brown, thick, reticulate.

South Africa, Transkei.

15. ZYGNEMA AREOLATUM Taft & Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 210, Pl. 17, Fig. 8.

Vegetative cells 27–30 μ x 46–66 μ; conjugation scalariform; zygospores formed in the conjugating tubes, globose to ovoid, 32–46 μ x 33–50 μ; median spore wall brown, of 2 layers, of which the outer is

pitted; pits 5–6 μ in diameter, 1.5–3 μ apart, the inner layer densely and minutely verrucose. (Pl. III, Fig. 5.)

United States: Oklahoma.

16. ZYGNEMA LAETEVIRENS Klebs 1886. *Untersuch. Bot. Inst. Tübingen.* **2**, p. 333, Pl. 3, Fig. 14.

Vegetative cells 27–34 μ x 40–90 μ; conjugation scalariform; zygospores formed in the conjugating tubes, globose, 40–55 μ in diameter, or ovoid, 34–41 μ x 54–68 μ; median spore wall chestnut brown, of 2 layers, of which the inner is finely verrucose, the outer scattered-scrobiculate. It is probable that the ornamentation of the inner median wall arises from granules formed between the 2 layers. The same may be true of Numbers 9 and 15.

United States: Indiana; Ohio; Mississippi; Alabama.

Europe; Australia; China (L. C. Li Coll.).

Spores may be yellow before the verrucose markings of the inner median wall appear. The Indiana specimens contained many parthenospores similar to the zygospores but smaller.

17. ZYGNEMA PECTINATUM (Vaucher) Agardh 1817. *Synopsis Algarum,* p. 102.

Vegetative cells 30–36 μ x 25–120 μ; conjugation scalariform, rarely lateral; zygospores formed in the conjugating tubes, globose to ovoid, 35–44 μ x 40–54 μ; median spore wall brown, scrobiculate; pits about 2–3 μ in diameter; aplanospores ovoid or cylindric, 30–38 μ x 30–60 μ; walls similar. (Pl. III, Fig. 6.)

United States: Generally distributed eastward from Minnesota, Nebraska, Oklahoma, and Louisiana.

Widely distributed in Europe, Asia, Africa, and South America.

18. ZYGNEMA EXCRASSUM Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 209, Pl. 17, Fig. 14.

Vegetative cells 32–36 μ x 32–80 μ; conjugation scalariform; zygospores formed in the conjugating tubes, usually ovoid, rarely globose (40–)50–60 μ x 50–70(–80) μ; median spore wall brown, scrobiculate; pits 3–4 μ in diameter and about the same distance apart; aplanospores cylindric-ovoid, nearly filling the sporogenous cells. (Pl. III, Fig. 7.)

United States: Oklahoma; Illinois; Iowa; Mississippi; Alabama.

19. ZYGNEMA NEOPECTINATUM Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 209, Pl. 17, Fig. 7.

Vegetative cells 40–45 μ x 40–85 μ; conjugation scalariform; zygospores formed in the conjugating tubes, ovoid to globose, 45–54 μ x

55–60 μ; median spore wall brown, scrobiculate; pits about 3 μ in diameter. (Pl. III, Fig. 8.)

United States: Illinois.

20. Zygnema giganteum Randhawa 1936. *Proc. Indian Acad. Sci.* 4, p. 241.

Vegetative cells 40–48 μ x 56–90 μ; reproduction by zygospores and aplanospores; conjugation scalariform; zygospores formed in the conjugating tubes; zygospores ovoid to globose, 48–64 μ x 56–70 μ; median wall yellow-brown, of 2 layers, of which the outer is undulate pitted and the inner smooth or granulate. The other 2 walls are transparent. Aplanospores cylindric, filling the cells, with walls similar to those of the zygospores, 38–48 μ x 45–72 μ. (Pl. III, Figs. 9–10.)

India, Kapurthala State, Punjab, March, 1931.

This description is modified from the original on the basis of specimens kindly sent by Mr. Randhawa. Associated with this species in the original collection is an anisogamous species with very peculiar conjugating tubes, in that a ring of pectic material surrounds the tube at the point of union. This is indicated by Randhawa's figures. However, there are no ripe spores in the material that I have seen and because of the smaller zygospores I believe it is a distinct and unnamed species.

21. Zygnema gedeanum Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 115, Fig. 118.

Vegetative cells 13–15 μ x 32–34 μ; conjugation lateral; zygospores formed in the conjugating tubes, ovoid, 22–24 μ x 30–32 μ; median spore wall blue to blue-black, thick, pitted; pits about 1 μ in diameter. (Pl. III, Figs. 11–12.)

Java.

22. Zygnema cyanosporum Cleve 1868. *Nova Acta Reg. Soc. Sci. Upsali.* 6, p. 28, Pl. 8, Figs. 6–8.

Vegetative cells about 20–22 μ x 40–180 μ; conjugation scalariform; zygospores formed in the conjugating tubes, globose, rarely quadrate-globose, 30–40 μ in diameter; median spore wall blue, thick, smooth.

United States: Michigan.

Greenland; Sweden; Finland; India; South Africa.

23. Zygnema czurdae Randhawa 1936. *Proc. Indian Acad. Sci.* 4, p. 239.

Vegetative cells 20–27 μ x 30–100 μ, with 2 chromatophores; conjugation lateral and scalariform; spores formed in the tubes; during lateral conjugation the intergametangial wall splits and the gametangia are connected only by the enlarged tubes; in scalariform conjugation the

spores are formed in the tubes; zygospores globose, 30–40 μ in diameter, all walls smooth and light blue in color. (Pl. III, Figs. 13–14.)

India, Punjab, February, 1931.

These spores may not be mature and the color may be due to refraction of light rather than the presence of a blue pigment.

24. Zygnema synadelphum Skuja 1926. *Acta Horti Bot. Univ. Latviensis.* 1, p. 110, Pl. 1, Fig. 2.

Vegetative cells 17–21 μ x 34–120 μ; conjugation scalariform; zygospores formed in the conjugating tubes, ovoid to spheroid, 27–36 μ x 34–44 μ; median spore wall blue, of 3 layers, of which the outer is irregularly punctate; pits about 1–2 μ in diameter; suture sometimes prominent, usually not. Aplanospores cylindric-ovoid, filling the vegetative cells, otherwise similar to the zygospores. (Pl. IV, Figs. 1–2.)

United States: Oklahoma; Texas; Michigan; Ohio; Louisiana; Florida. Latvia; China; Africa, Burma.

In a collection from Alexandria, Louisiana, aplanospores were very abundant. In a collection from Florida most of the spores were in the tubes, but occasional spores were in the gametangia of both conjugating filaments.

25. Zygnema terrestre Randhawa 1938. *Proc. Indian Acad. Sci.* 8, p. 147, Fig. 29.

Vegetative cells 18–24 μ x 36–60 μ; conjugation scalariform, zygospores in the tubes or extending into the gametangia, subglobose to ovoid, 28–38 μ x 36–54 μ; median wall blue when mature, brownish when immature, punctate with pits .5–1 μ in diameter 3–5 μ apart; aplanospores ovoid to dolioform, formed in the enlarged middle part of the cells; the outer wall of the cell adjoining the spore changes to pectic compound forming a collar. When mature the aplanospore walls are similar to those of the zygospores. Aplanospores are 30–34 μ x 36–65 μ. Some filaments have several of the lowermost cells with disintegrating chromatophores beneath the soil surface. (Pl. VII, Figs. 16–18.)

India, Fyzabad, forming a light green felt on the soil surface of fallow fields at the close of the rainy season, late September and October, 1937.

26. Zygnema coeruleum Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 107, Fig. 107.

Vegetative cells 24–26 μ x 40–55 μ in diameter; conjugation scalariform; zygospores formed in the conjugating tubes, ovoid to globose, 32 μ x 32–35 μ; median spore wall blue, thick, scrobiculate; pits 1.5 μ in diameter, 2 diameters apart. (Pl. IV, Figs. 3–4.)

Bohemia; South Africa; northern India.

27. ZYGNEMA GORAKHPORENSE Singh 1938. *Jour. Indian Bot. Soc.* **17**, p. 370.

Vegetative cells 23–27μ x 66–83μ; conjugation scalariform; zygospores formed in the tubes and extending into the gametangia; zygospores ovoid to globose, 30–36μ x 36–43μ; median wall blue, scrobiculate; pits about 4μ in diameter and 1–3μ apart.

India, Gorakhpur, October 8, 1936.

28. ZYGNEMA MAJUS Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 106. Fritsch & Rich. *Trans. Roy. Soc. S. Africa,* **9**, p. 56. 1921.

Vegetative cells 27–30μ x 27–90μ; conjugation scalariform; zygospores formed in the conjugating tubes, globose to ovoid, 33–48μ x 42–50μ; median spore wall blue, smooth.

Africa, Transkei Territory.

29. ZYGNEMA KIANGSIENSE Li 1938. *Bull. Fan Mem. Inst. Biol.* **8**, p. 94.

Vegetative cells 32–38μ x 36–50μ; conjugation scalariform; zygospores formed in the conjugating tubes, ovoid to subglobose, 36–46μ x 44–58μ; median spore wall blue, coarsely scrobiculate; pits 3–5μ in diameter, 4–7μ apart. (Pl. IV, Fig. 5.)

China, Kiangsi.

30. ZYGNEMA RALFSII (Hassall) de Bary 1858. *Untersuchungen über die Familie der Conjugaten,* p. 77.

Vegetative cells 14–20μ x 38–80μ; conjugation scalariform; zygospores formed in the conjugating tubes, 15–25μ x 25–35μ; median spore wall brown, smooth. (Pl. IV, Fig. 6.)

United States: Pennsylvania, Harrisburg (Wolle).

British Isles and continental Europe.

31. ZYGNEMA MICROPUNCTATUM Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 210, Pl. 17, Fig. 13.

Vegetative cells 14–16μ x 24–52μ; conjugation scalariform; zygospores formed in the greatly enlarged conjugating tubes, compressed-globose, with the longer diameter at right angles to the conjugating tube, 28–32μ x 36–40μ; median spore wall yellow-brown, minutely and densely punctate. (Pl. IV, Fig. 7.)

United States: Michigan; Oklahoma.

32. ZYGNEMA MOMONIENSE W. West 1892. *Jour. Linn. Soc. of London Bot.* **29**, p. 114, Pl. 24, Fig. 26.

Vegetative cells 20–22μ in diameter; conjugation scalariform; zygo-

spores formed in the conjugating tubes, compressed-globose, with the longer diameter at right angles to the conjugating tubes; 25–27μ x 30–33μ; median spore wall [?] brown, smooth.

Ireland.

33. Zygnema circumcarinatum Czurda 1930. *Beih. Bot. Zentralbl.* 47, p. 53, Fig. 15.

Vegetative cells 20–22μ in diameter; conjugation scalariform; zygospores formed in the conjugating tubes, globose or compressed-globose, 24μ to 29μ in diameter; median spore wall golden-brown, thick, scrobiculate, with pits 2–2.5μ in diameter and 1–2μ apart; spore wall more or less carinate. As the spores mature the tube walls change to pectic compounds and form persistent colloidal walls as thick as the spores themselves. This often results in separation of the spores from their subtending gametangia. Aplanospores similar but smaller, often maturing outside the sporogenous cell. (Pl. IV, Figs. 8–9.)

United States: Texas, Eden, April 13, 1938 (Taft Coll.).

Bohemia.

In *Handbuch der Pflanzenanatomie* (6, *Conjugatae*) Czurda discusses and figures stages in conjugation, and germination of spores of this species, which he had cultivated.

Exactly similar stages in spore maturation occur in several species of *Mougeotia* (Pl. XVII). Note that the spores are also of the compressed type.

34. Zygnema pawhuskae Taft 1934. *Trans. Amer. Micros. Soc.* 53, p. 209, Pl. 21, Fig. 61.

Vegetative cells 21–24μ x 40–60μ; conjugation scalariform; zygospores formed in the conjugating tubes, ovoid to compressed-globose, extending into the gametangia, 34–48μ x 46–65μ; median spore wall seal-brown, of 2 layers, the outer smooth with a distinct equatorial suture, the inner densely and minutely verrucose, sometimes reticulate-verrucose. During the early stages of conjugation the outer sporangium wall is a pectic layer 3–6μ in thickness. (Pl. IV, Fig. 10.)

United States: Oklahoma.

35. Zygnema carinatum Taft 1934. *Trans. Amer. Micros. Soc.* 53, p. 210, Pl. 17, Fig. 9.

Vegetative cells 16–18μ x 33–36μ; conjugation scalariform; zygospores formed in the conjugating tubes, compressed-globose, with the longer axis at right angles to the conjugating tube, 23–26μ x 29–33μ; median spore wall blue, punctate, and encircled by a prominent suture. During development the sporangium wall is encased in a pectic layer 3–6μ in thickness. (Pl. IV, Fig. 11.)

United States: Oklahoma.

36. Zygnema stagnale (Hassall) Kützing 1849. *Species Algarum,* p. 444.

Vegetative cells 9–12 μ x 20–50 μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia enlarged on the inner side; zygospores globose to subglobose, 14–18 μ x 14–20 μ; median spore wall brown, punctate.

United States: Massachusetts, North Eastham (Collins Coll.).

England.

37. Zygnema subtile Kützing 1849. *Species Algarum,* p. 444.

Vegetative cells 14–20 μ x 30–85 μ; conjugation scalariform or very rarely lateral; zygospores in one of the gametangia; receptive gametangia greatly enlarged or inflated on the inner side; zygospores ovoid to subglobose, 20–29 μ x 22–30 μ; median spore wall brown, punctate.

United States: Illinois.

Finland; Germany; Bohemia.

This is possibly the species figured by G. S. West (1909) as *Z. spontaneum* from Yan Yean Reservoir, Australia. In a collection from Calhoun, Illinois, in a filament of 35 cells there were 11 gametangia with scalariform conjugation, 2 pairs conjugating laterally, and 20 vegetative cells scattered among them.

38. Zygnema cylindrospermum (W. & G. S. West) Krieger 1941. *Zygnemales. Rabenhorst's Kryptogamenflora.* 13, p. 260.

Vegetative cells 15–18 μ in diameter; conjugation scalariform; zygospores formed in one of the gametangia; receptive gametangia cylindric or slightly enlarged; zygospores ovoid, 15–19 μ x 23–54 μ; median spore wall brown, punctate. (Pl. IV, Fig. 16.)

Shetlands (Loch Asta); Wales (Wittrock and Nordstedt No. 750); Cape Colony (Stephens Coll.).

39. Zygnema yunnanense Li 1940. *Bull. Fan Mem. Inst. Biol.* **10**, p. 63.

Vegetative cells 16–18 μ x 50–104 μ; conjugation lateral; receptive gametangia more or less enlarged; zygospores globose to ovoid, 32–40 μ x 38–48 μ; median wall thick, deeply scrobiculate, with pits 3–4.5 μ in diameter, 2–3 μ apart, yellow at maturity.

China, Yünnan, October 1, 1938.

40. Zygnema extenue Jao 1935. *Sinensia.* **6**, p. 568, Pl. 1, Fig. 8.

Vegetative cells 19–25 μ x 32–48 μ; conjugation scalariform and sometimes lateral; receptive gametangia more or less enlarged; zygospores subglobose to ovoid, 23–32 μ x 26–39 μ; median spore wall scro-

biculate; pits 4.5–6.5μ in diameter and 2–3μ apart, yellow-brown at maturity. (Pl. IV, Fig. 12.)

China, Szechwan.

41. Zygnema tholosporum Magnus & Wille 1884. *Sydamerica Algflora,* p. 33, Pl. 1, Figs. 49–52.

Vegetative cells 20μ x 20–40μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia inflated; zygospores globose, 36μ in diameter; median spore wall brown, with numerous circular prominences (umbonate). (Pl. IV, Fig. 13.)

Uruguay, Montevideo.

42. Zygnema tenue Kützing 1849. *Species Algarum,* p. 445.

Vegetative cells 18–24μ x 20–70μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia greatly enlarged or inflated toward the middle; zygospores globose to ovoid, often somewhat compressed, 25–30μ x 25–40μ; median spore wall brown, scrobiculate; pits 2–3μ in diameter, 3–4μ apart. (Pl. IV, Figs. 14–15.)

United States: Illinois; Oklahoma.

Europe, widely reported; North and South Africa; China; Ceylon.

43. Zygnema leiospermum de Bary 1858. *Untersuchungen über die Familie der Conjugaten,* p. 77, Pl. 1, Figs. 7–14.

Vegetative cells 20–24μ x 20–40μ; conjugation scalariform; zygospores in one of the greatly enlarged or inflated gametangia; zygospores globose to ovoid, 23–30μ x 23–32μ; median spore wall brown, smooth; aplanospores similar, but smaller in diameter.

United States: Minnesota and Illinois to the east coast.

Greenland; Iceland; British Isles; continental Europe.

44. Zygnema hausmannii (De Notaris) Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 121, Fig. 125.

Vegetative cells 21–23μ x 34–72μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia enlarged mostly on the inner side; zygospores globose or slightly compressed, 32–34μ x 28–34μ; median spore wall yellow-brown, pitted; pits 7–9μ in diameter; equatorial suture distinct. (Pl. IV, Figs. 17–18.)

Austria; northern Italy; southern Australia.

45. Zygnema substellinum Taft 1934. *Trans. Amer. Micros. Soc.* 53, p. 212, Pl. 17, Fig. 10.

Vegetative cells 22–24μ x 50–70μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia greatly enlarged, becoming nearly globose; zygospores globose, filling or nearly filling

the gametangia, 42–46μ in diameter; median spore wall yellow-brown, scrobiculate; pits 3μ in diameter. (Pl. V, Fig. 1.)

United States: Oklahoma, Bartlesville, April 25, 1932.

This species is remarkable for the large size of the zygospores as compared with the size of the vegetative cells.

46. Zygnema luteosporum Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 122, Fig. 225.

Vegetative cells 22–24μ x 45–80μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia cylindric or slightly enlarged; zygospores ovoid, 26μ x 38μ; median spore wall yellow, thick, scrobiculate, with pits widely spaced. (Pl. V, Fig. 2.)

Bohemia.

47. Zygnema flavum Taft 1946. *Trans. Amer. Micros. Soc.* **65**, p. 24.

Vegetative cells 22–27μ x 48–68μ; conjugation scalariform; zygospores formed in one of the gametangia; receptive gametangia cylindric or slightly enlarged; zygospores cylindric-ovoid to ovoid, 24–29μ x 35–51μ; outer spore wall thin and smooth; median spore wall of 2 layers, the outer thick and smooth, the inner irregularly verrucose; both layers light yellow; innermost spore wall thin, smooth. (Pl. V, Fig. 3.)

United States: Texas, Eden, April 13, 1938. In this collection some of the vegetative cells contained 4 chromatophores.

48. Zygnema calosporum Jao 1935. *Sinensia.* **6**, p. 568, Pl. 1, Fig. 7.

Vegetative cells 23–26μ x 16–48μ; conjugation scalariform; receptive gametangia shortened and greatly enlarged; zygospores globose to subglobose, 29–35μ x 32–35μ; median spore wall densely scrobiculate; pits 1.5–2.5μ in diameter, 1–1.5μ apart, yellowish-brown at maturity. (Pl. V, Fig. 4.)

China, Szechwan.

Differs from *Z. substellinum* Taft in greater diameter of the vegetative cells and smaller spores; from *Z. vaucherii* in shorter vegetative and reproductive cells, and in denser scrobiculations of the median spore wall.

49. Zygnema vaucherii Agardh 1824. *Systema Algarum,* p. 77.

Vegetative cells 24–28μ x 50–180μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia gradually or abruptly inflated toward the middle; zygospores ovoid, 24–36μ x 26–45μ; median spore wall brown, scrobiculate; pits 2–3μ in diameter. (Pl. V, Fig. 5.)

United States: Illinois; Indiana; Ohio; Massachusetts.

Widely reported from Europe.

50. Zygnema normani Taft 1934. *Trans. Amer. Micros. Soc.* **53**, p. 213, Pl. 17, Fig. 12.

Vegetative cells 24–28μ x 30–73μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia greatly inflated on the conjugating side; zygospores globose or subglobose, 36–46μ x 35–45μ; median spore wall yellow-brown, scrobiculate; pits 3–4μ in diameter, 2.5–4μ apart. (Pl. V, Fig. 6.)

United States: Oklahoma.

India.

51. Zygnema insignisporum Couch 1944. *Ohio Jour. Sci.* **44**, p. 277.

Vegetative cells 24–28μ x 39–71μ; conjugation scalariform; receptive gametangia inflated on the conjugating side; zygospores globose to ovoid, 32–35μ x 32–35μ; outer wall of 2 colorless layers, of which the outermost is smooth, the inner scrobiculate, with pits 4–5μ in diameter and about 7μ apart; median wall punctate, yellow.

United States: Arkansas.

52. Zygnema vaginatum Klebs 1886. *Untersuch. Bot. Inst. Tübingen.* **2**, p. 135, Pl. 3, Fig. 13. *Notarisia.* **1**, pp. 340–41. 1886.

Vegetative cells 25–27μ x 37–75μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia slightly enlarged; zygospores globose to ovoid, diameter about 28μ; median spore wall brown, verrucose-tuberculate.

Germany; Austria.

Czurda (1932) and Krieger (1941) described this species as having scrobiculate median spore walls. No reason for the change from the original description is given.

53. Zygnema subcruciatum Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 212.

Vegetative cells 24–30μ x 26–60μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia cylindric or enlarged, mostly on the inner side; zygospores globose to ovoid, 25–32μ x 28–40μ; median spore wall brown, finely scrobiculate. (Pl. V, Fig. 7.)

United States: Oklahoma; Texas; Arkansas; Louisiana; Illinois; Ohio.

France; Norway; Sweden; China.

54. Zygnema germanicum Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 125, Fig. 129.

Vegetative cells 26–28 μ x 30–36 μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia greatly enlarged or inflated; zygospores globose or compressed-globose, 36–38 μ x 36–45 μ; median spore wall brown, thick, pitted; pits 6–7 μ in diameter. (Pl. V, Figs. 8–9.)

Germany; Czechoslovakia.

55. Zygnema insigne (Hassall) Kützing 1849. *Species Algarum,* p. 444.

Vegetative cells 26–32 μ x 26–60 μ; conjugation scalariform or lateral; zygospores in one of the gametangia; receptive gametangia cylindric or enlarged; zygospores globose or subglobose, 27–33 μ x 27–35 μ; median spore wall yellow-brown, smooth; aplanospores 28–33 μ, ovoid to cylindric-ovoid, otherwise similar. (Pl. V, Figs. 10–12.)

United States: California to Massachusetts and New Jersey.

Widely reported from Europe, Australia, South America, and China.

Many of the records of this species are based on specimens with immature, colorless spores. These specimens should not have been named.

56. Zygnema fanicum Li 1934. *Trans. Amer. Micros. Soc.* **53**, p. 212, Pl. 18, Figs. 17–19.

Vegetative cells 28–33 μ x 28–80 μ; conjugation usually scalariform, sometimes lateral; zygospores in one of the gametangia; receptive gametangia cylindric or enlarged; zygospores globose to ovoid, 30–36 μ x 34–42 μ; median spore wall yellow, sharply pitted; pits 4–7 μ in diameter, 2–3 μ apart, each with a distinct, raised margin; aplanospores similar to zygospores. (Pl. V, Figs. 13–14.)

China, Hupeh, Kiangsi, Anhwei, Szechwan, Shantung.

57. Zygnema subfanicum Jao 1940. *Sinensia.* **11**, p. 295, Pl. 4, Fig. 1.

Vegetative cells 24–26 μ x 30–65 μ, with 2 stellate chromatophores; conjugation scalariform; spores formed in one of the gametangia; receptive gametangia enlarged on the conjugating side; zygospores globose to subglobose, 29–35 μ in diameter; median wall pitted; pits 7–8 μ in diameter, 1.8–2.7 μ apart, yellow-brown in color. (Pl. V, Fig. 15.)

China, Hunan.

58. Zygnema transeauianum G. C. Couch 1944. *Ohio Jour. Sci.* **44**, p. 277.

Vegetative cells 30–32 μ x 20–60 μ; conjugation scalariform; receptive gametangia enlarged or slightly inflated on the conjugating side;

zygospores globose to ovoid, 25–35μ x 33–40μ, somewhat compressed; median spore wall yellow-brown, reticulate, with large irregular pits 7–12μ across.

United States: Arkansas, Boston Mountains.

59. Zygnema stellinum (Vaucher) Agardh 1824. *Systema Algarum,* p. 77.

Vegetative cells 28–38μ x 27–100μ; conjugation scalariform, rarely lateral between occasional pairs of cells; zygospores in one of the gametangia; receptive gametangia inflated especially on the conjugating side; zygospores ovoid, 30–42μ x 35–48(–57)μ; median spore wall yellow-brown, thick, scrobiculate; pits 3–4μ in diameter, 3–4μ apart; aplanospores common, usually cylindric, very rarely globose, the former filling the sporogenous cells, the latter occupying the middle of the cells; spore walls similar to those of the zygospores. (Pl. I, Fig. 8; Pl. V, Fig. 16; and Pl. VI, Fig. 1.)

United States: Washington and California eastward, very common in the central and eastern states.

Canada; Greenland; Europe; Asia; South America; North Africa.

60. Zygnema cruciatum (Vaucher) Agardh 1817. *Synopsis Algarum,* p. 102.

Vegetative cells 30–36μ x 30–60μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia cylindric or enlarged; zygospores globose to ovoid, 30–38μ x 32–40μ; median spore wall brown, scrobiculate; pits 1.5–2μ in diameter, 3–5μ apart; aplanospores short, cylindric-ovoid, 30–35μ x 30–60μ, filling the vegetative cells, otherwise similar to the zygospores. (Pl. I, Fig. 9.)

United States: Oklahoma; Iowa; Illinois; Massachusetts south to Mississippi and Florida.

Reported from all the continents.

61. Zygnema cylindrosporum Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 122, Fig. 126.

Vegetative cells 31–36μ x 60–80μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia cylindric or enlarged; zygospores short cylindric-ovoid to globose, 36–42μ x 42–60μ; median spore wall yellow-brown, scrobiculate; pits about 1.5–2μ in diameter, 3–5μ apart; suture obliquely encircling the smaller circumference of the spore. (Pl. VI, Fig. 2.)

Macedonia; northern India; South Africa.

62. Zygnema bohemicum Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 124, Fig. 128.

Vegetative cells 31–33μ x 45–95μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia cylindric or enlarged on the conjugating side; zygospores ovoid to cylindric-ovoid, 32–36μ x 42–60μ; median spore wall yellow-brown, thick, outwardly shallow pitted (visible only in section), and densely and finely verrucose. (Pl. VI, Fig. 3.)

Czechoslovakia.

63. Zygnema mirandum Taft 1946. *Trans. Amer. Micros. Soc.* **65**, p. 24.

Vegetative cells 28–35μ x 32–64μ; conjugation scalariform; zygospores formed in one of the gametangia; receptive gametangia greatly enlarged on the conjugating side; zygospores compressed-globose to ovoid; median wall carinate; spore wall thin and smooth; median spore wall yellow-brown, of 2 layers, the outer thick and smooth, the inner reticulate, with the thin ridge crests irregularly broken; innermost spore wall smooth. (Pl. VI, Fig. 4.)

United States: Texas, Austin and Fredericksburg, April 22–24, 1938.

64. Zygnema inconspicuum Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 122, Fig. 127.

Vegetative cells 36–39μ x 50–70μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia cylindric or scarcely enlarged; zygospores ovoid, sometimes extending into the enlarged tube, 40μ x 50–60μ; median spore wall brown, pitted; pits 4–5μ in diameter, 4–5μ apart. (Pl. VI, Fig. 5.)

Finland; Manchuria; northern India.

See also Number 86.

65. Zygnema neocruciatum Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 212.

Vegetative cells 40–50μ x 30–100μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia cylindric or slightly enlarged; zygospores globose to cylindric-ovoid, filling the gametangia, 40–45μ x 40–50μ; median spore wall brown, scrobiculate; pits about 2μ in diameter, 3–4μ apart; aplanospores common and similar in size, rarely to 80μ in length.

United States: Illinois. Probably included in many records for *Z. cruciatum* elsewhere.

See also Number 86.

66. Zygnema crassiusculum Transeau 1938. *Amer. Jour. Bot.* **25**, p. 524, Fig. 3.

Vegetative cells 52–58μ x 52–144μ; conjugation scalariform; zygo-

spores formed in one of the gametangia, compressed-globose to compressed-ovoid, 54–58 μ x 54–65 μ x 47–55 μ; median spore wall brown, of 2 layers, of which the outer is scrobiculate; pits about 2 μ in diameter, the inner finely and irregularly verrucose. (Pl. VI, Figs. 6–7.)

Africa, Cape Town (E. L. Stephens Coll.).

67. Zygnema atrocoeruleum W. & G. S. West 1897. *Jour. Roy. Micros. Soc. London,* p. 476.

Vegetative cells 14–17 μ x 40–70 μ in diameter; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia enlarged or inflated; zygospores globose, 23–26(–29) μ in diameter; median spore wall dark blue, smooth.

England.

68. Zygnema chalybeospermum Hansgirg 1888. *Hedwigia.* **27,** p. 253.

Vegetative cells 24–27 μ x 24–84 μ; conjugation scalariform or lateral; zygospores in one of the gametangia; receptive gametangia cylindric or enlarged; zygospores globose to ovoid, 30–33 μ x 30–38 μ; median spore wall blue, thick, smooth. (Pl. VI, Fig. 8.)

United States: Illinois, Casey; Michigan (Ackley Coll.).

Europe; Asia; North Africa.

69. Zygnema cyaneum Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 127, Fig. 132.

Vegetative cells 30–32 μ x 45–60 μ; conjugation scalariform or lateral; zygospores in one of the gametangia; receptive gametangia cylindric or slightly enlarged; zygospores globose to cylindric-ovoid, 30–34 μ x 38–45 μ; median spore wall blue, thick, smooth. (Pl. VI, Figs. 9–10.)

Bohemia; India.

70. Zygnema collinsianum Transeau 1914. *Amer. Jour. Bot.* **1,** p. 289, Pl. 25, Figs. 1–3.

Vegetative cells 18–25 μ x 32–80 μ; conjugation scalariform; zygospores mostly in one of the gametangia, sometimes in one filament, sometimes in the other, rarely in conjugating tube, extending into both gametangia; receptive gametangia enlarged on the conjugating side; zygospores globose to ovoid, sometimes slightly compressed and showing a distinct equatorial suture, 26–40 μ x 30–47 μ; median spore wall blue at maturity, thick, pitted; pits 4–5 μ in diameter, 1–2 μ apart; aplanospores cylindric-ovoid, 18–24 μ x 40–76 μ, scattered among the vegetative cells, similar in markings to zygospores. (Pl. VI, Figs. 11–13.)

United States: Oklahoma; Illinois; Indiana; Kentucky; Alabama.

Northern India (Randhawa).

Named in honor of Frank S. Collins, author of *Freshwater Algae of the United States* and many contributions to both marine and fresh-water algology.

71. ZYGNEMA MELANOSPORUM Lagerheim 1884. *Bot. Zentralbl.* **18**, p. 279.

Vegetative cells 22–27μ x 36–100μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia cylindric or slightly enlarged; zygospores ovoid to cylindric-ovoid, 23–30μ x 28–36μ; median spore wall dark blue, finely punctate.

United States: Ohio, Fayetteville, May, 1934.

Sweden; North Africa.

72. ZYGNEMA EXCOMPRESSUM Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 213.

Vegetative cells 23–26μ x 32–80μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia cylindric or enlarged; zygospores globose to subglobose, more or less compressed in the plane of the conjugating tube, 28μ x 28–36μ; median spore wall blue, carinate, scrobiculate; pits 2.5–3μ in diameter and about the same distance apart. (Pl. VI, Fig. 14.)

United States: Oklahoma, Medford, April 26, 1932 (Taft Coll.).

Bohemia.

73. ZYGNEMA PELIOSPORUM Wittrock 1868. *Bot. Notiser.* p. 190.

Vegetative cells 23–30μ x 24–80μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia enlarged, or inflated on the conjugating side; zygospores globose to ovoid, slightly compressed, 28–36μ x 28–46μ; median spore wall blue, finely scrobiculate or punctate, with pits 1–2μ in diameter, spaced 2–3μ apart; equatorial suture usually distinct, sometimes prominent; aplanospores cylindric-ovoid, smaller and with similar markings. (Pl. VI, Fig. 17.)

United States: California; Colorado; Texas; Indiana; Alabama.

Sweden; Hungary; Spain; France; Norway; Finland; China.

74. ZYGNEMA AZUREUM Taft 1934. *Trans. Amer. Micros. Soc.* **53**, p. 214, Pl. 17, Fig. 3.

Vegetative cells 26–29μ x 46–66μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia slightly to greatly enlarged; zygospores ovoid to cylindric-ovoid, 27–33μ x 33–50μ; median spore wall blue, finely punctate. (Pl. VI, Fig. 15.)

United States: Oklahoma; Illinois.

75. ZYGNEMA CARINTHIACUM Beck 1929. *Archiv f. Protist.* **66**, p. 1.

Vegetative cells 25–30μ x 25–100μ; conjugation scalariform; zygo-

spores in one of the gametangia; receptive gametangia much enlarged; zygospores globose to ovoid, 32–45 μ x 36–52 μ; median spore wall blue, scrobiculate; pits 3–4 μ in diameter, 3–5 μ apart. (Pl. VI, Fig. 16.)

United States: Oklahoma; Texas; Mississippi; Ohio; Florida.

Austria; China.

Forms with the same vegetative characters, but with smaller spores, have been collected in Ohio and Oklahoma.

76. Zygnema pawneanum Taft 1934. *Trans. Amer. Micros. Soc.* **53**, p. 214, Pl. 18, Fig. 16.

Vegetative cells 26–28 μ x 33–88 μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia greatly enlarged on the inner side; zygospores globose, subglobose, or rarely ovoid, 36–46 μ x 36–48 μ; median spore wall blue when mature, pitted; pits 7–11 μ in diameter, 2–3 μ apart. (Pl. VII, Fig. 1.)

United States: Oklahoma; Louisiana (Taft Coll.); Ohio; Florida (J. D. Smith Coll.).

In the Ohio collection some of the spores were distinctly tricarinate. The pits may be round or somewhat angular depending upon the height of the ridges between the pits.

77. Zygnema ornatum (Li) Transeau 1934. *Ohio Jour. Sci.* **34**, p. 420. Li. *Ohio Jour. Sci.* **33**, p. 153, Pl. 1, Figs. 9–10. 1933.

Vegetative cells 27–32 μ x 34–96 μ; conjugation scalariform; zygospores in one of the gametangia; receptive gametangia enlarged on the inner side, or cylindric; zygospores globose, subglobose to ovoid, 28–38 μ x 32–38 μ; median spore wall blue, pitted; pits about 6 μ in diameter and about 2 μ apart. (Pl. VII, Fig. 2.)

United States: Oklahoma; Louisiana; Mississippi; Alabama.

China, Nanking (L. C. Li Coll.).

78. Zygnema excommune Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 213. Czurda. *Süsswasserflora Mitteleuropa.* p. 119 (as *Z. commune*).

Vegetative cells 30–32 μ x 55–90 μ; conjugation scalariform; zygospores formed in one of the gametangia; receptive gametangia greatly enlarged on the conjugating side; zygospores globose to ovoid, 40 μ x 50 μ; median spore wall blue, thick, scrobiculate; pits about 2.5 μ in diameter, about 4 μ apart, according to the figure. (Pl. VII, Fig. 3.)

Bohemia.

79. Zygnema catenatum Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 213.

Vegetative cells 30–36 μ x 35–80 μ; conjugation scalariform; zygo-

spores in one of the gametangia; receptive gametangia slightly enlarged on the conjugating side; zygospores globose to ovoid, slightly compressed, 30–36μ x 30–46μ; median spore wall blue, scrobiculate; pits 1.5–2μ in diameter, 2–4μ apart; aplanospores similar, 30–34μ x 30–80μ, filling the cells.

United States: Illinois.

SPECIES REPRODUCING BY APLANOSPORES

80. ZYGNEMA FRIGIDUM Taft 1934. *Trans. Amer. Micros. Soc.* 53, p. 214, Pl. 17, Fig. 11.

Vegetative cells 21–23μ x 29–83μ; conjugation unknown; reproduction by aplanospores, cylindric to tumid-cylindric with rounded ends, 22–24μ x 24–44μ; median spore wall blue, scrobiculate; pits 1.5–2μ in diameter, 3–4μ apart. (Pl. 1, Fig. 6.)

United States: Oklahoma; Texas.

81. ZYGNEMA SPONTANEUM Nordstedt 1878. *De Algis et Characeis Sandwicensibus,* p. 17, Pl. 1, Figs. 23–24.

Vegetative cells 16–22μ x 28–90μ; reproduction by aplanospores only; aplanospores ovoid to cylindric-ovoid, 18–22μ x 22–32μ; median spore wall brown, scrobiculate; pits about 2μ in diameter, 3–5μ apart. (Pl. VII, Figs. 5–7.)

Hawaii; South Africa (E. Stephens Coll.); Java (Czurda); China (Jao).

At all the above stations this species produced only aplanospores. The illustrations, published by G. S. West (1909) under this name, showing scalariform conjugations are better illustrations of *Z. subtile* than of this species. Nordstedt's original collection from Hawaii had cell diameters of 16–18μ; the South African material, 18–20μ; and the Szechwan specimens, 19–22μ.

82. ZYGNEMA CYLINDRICUM Transeau 1915. *Ohio Jour. Sci.* 16, p. 22.

Vegetative cells 28–33μ x 28–66μ; conjugation unknown; reproduction by akinetes and aplanospores; aplanospores cylindric to tumid-cylindric, filling the cell, 30–33μ x 24–54μ; median spore wall brown, scrobiculate; pits about 3μ in diameter; suture irregular. (Pl. VII, Fig. 9.)

United States: Illinois; Indiana; Kentucky; Ohio. Common and generally distributed in April and May.

South America, south Chile.

83. ZYGNEMA STERILE Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 212.

Vegetative cells 44–54μ x 22–69μ with heavy cell walls, often with

an outer pectic layer 6–15μ in thickness; conjugation unknown; reproduction by akinetes; akinetes heavy-walled, completely filling the cells, brown at maturity, often distinctly colligate. (Pl. VII, Fig. 11.)

United States: Prairie regions of Oklahoma; Texas; Wisconsin; Michigan; Illinois; Indiana; Ohio. Not uncommon.

Greece (Skuja, 1937); Asia Minor (Skuja, 1932).

The brown color of the akinetes apparently results from chemical changes in the protoplasts and chromatophores. I have had this alga in cultivation during 2 successive years. It grew well, produced akinetes, which germinated and produced new filaments. During a 5 year period near Columbus, Ohio, it grew abundantly in a pond, but produced no spores.

84. Zygnema quadrangulatum Jao 1940. *Sinensia.* **11**, p. 294, Pl. 4, Fig. 3.

Vegetative cells 24–27μ x 25–100μ, with 2 stellate chromatophores; reproduction by aplanospores only; aplanospores cylindric-ovoid, 25–29μ x 20–28μ; median spore wall dark blue, smooth, lamellate. (Pl. VII, Fig. 14.)

China, Hunan.

85. Zygnema hypnosporum Rich 1935. *Trans. Roy. Soc. S. Africa.* **23**, p. 125.

Vegetative cells about 33μ in diameter, with 2 large stellate chromatophores; reproduction by aplanospores only; aplanospores cylindric-ovoid, 34μ x 34–70μ; median wall scrobiculate, blue. (Pl. VII, Fig. 12.)

Africa, South Rhodesia, July 3, 1930 (Stephens Coll.).

86. Zygnema schwabei Krieger 1941. *Zygnemales. Rabenhorst's Kryptogamenflora.* 13, p. 261.

Vegetative cells 17–20μ x 36–71μ; reproduction by aplanospores only; spores cylindric filling the cells, 19–21μ x 37–70μ; median spore wall thick yellow-brown, scrobiculate, pits 1–3μ in diameter and 2–6μ apart, with several irregular sutures. (Pl. VII, Fig. 10.)

South America, southern Chile.

87. Zygnema borzae Krieger 1941. *Zygnemales. Rabenhorst's Kryptogamenflora.* 13, p. 264.

Vegetative cells 24–26μ x 18–55μ; reproduction by aplanospores only; aplanospores cylindric filling the sporangium wall, 14–27μ x 18–54μ; median wall thick, blue, punctate with irregular elongate and variously curved pits 0.5μ x 1–2μ in size. (Pl. VII, Fig. 4.)

Rumania, Transylvanian Alps at 6,000 feet, attached to stones in streams.

88. Zygnema subcylindricum Krieger 1941. *Zygnemales. Rabenhorst's Kryptogamenflora.* 13, p. 262.

Vegetative cells 28–35μ x 54–71μ; reproduction by aplanospores only; spores cylindric filling the cells, 29–33μ x 55–70μ; median wall brown, granulose and with shallow pits, and 1–2μ irregular sutures. (Pl. VII, Fig. 13.)

Germany; Bohemia.

This is the *Z. cylindricum* figured by Czurda. It differs from *Z. cylindricum* Transeau in the granulose markings on the spore wall.

89. Zygnema irregulare Krieger 1941. *Zygnemales. Rabenhorst's Kryptogamenflora.* 13, p. 263.

Vegetative cells 40–42μ x 68–82μ; reproduction by aplanospores only; spores cylindric-ovoid with very heavy walls; median wall brown, outwardly finely verrucose, with irregularly and widely separated pits 3–6μ in diameter and 4–26μ apart. (Pl. VII, Fig. 8.)

Germany, Mark Brandenburg.

SPECIES NOT IN PROPER SEQUENCE

90. Zygnema mucigenum Randhawa 1938. *Proc. Indian Acad. Sci.* **8**, p. 141, Fig. 25.

Vegetative cells 12–14μ x 50–100μ; conjugation both lateral and scalariform; zygospores in one of the gametangia, which is enlarged near the spore; zygospores compressed-globose, 20–22μ x 30–36μ; median spore wall dark blue-green, with scattered punctations; pits 1–1.5μ in diameter, 3–4μ apart. (Pl. XLI, Figs. 6–7.)

India, Fyzabad district, December 15, 1937.

Should be placed near Number 68.

91. Zygnema gangeticum Rao 1937. *Jour. Indian Bot. Soc.* **16**, p. 270.

Vegetative cells 16–20μ x 40–60μ; conjugation scalariform and lateral, zygospores formed in the conjugating tubes and extending into the gametangia; zygospores globose to ovoid, 30–36μ x 30–45μ; median spore wall yellow-brown and smooth.

India, United Provinces, Ganges.

Should be near Number 3.

92. Zygnema kwangtungense Ley 1944. *Sinensia.* **15**, p. 97.

Vegetative cells 38–42μ x 25–75μ; conjugation scalariform; receptive gametangia slightly inflated; zygospores globose or subglobose, slightly compressed, 44–61μ x 39–72μ; outer spore wall smooth, transparent; median wall 7–11μ thick, lamellate and foveolate; pits very

irregular in form and diameter, 1.8–6.5μ, 1.8–7.2μ apart, brown at maturity. (Pl. VII, Fig. 15.)

China, rice fields, Tong-Kau, North Kwangtung, March 20, 1942.

Should be near Number 61.

93. Zygnema ellipsoideum Jao 1947. *Bot. Bull. Acad. Sinica.* **1**, p. 97.

Vegetative cells 20–22μ x 25–40μ; conjugation unknown; aplanospores ellipsoid, with somewhat pointed ends, 15–20μ x 22–25(–30)μ; median spore wall yellow-brown, scrobiculate; sporiferous cells cylindric, or somewhat inflated on one side.

China, Kwangsi, Suijen, May 31, 1938; fairly common in rice fields.

This is the first species with ellipsoid spores to be described.

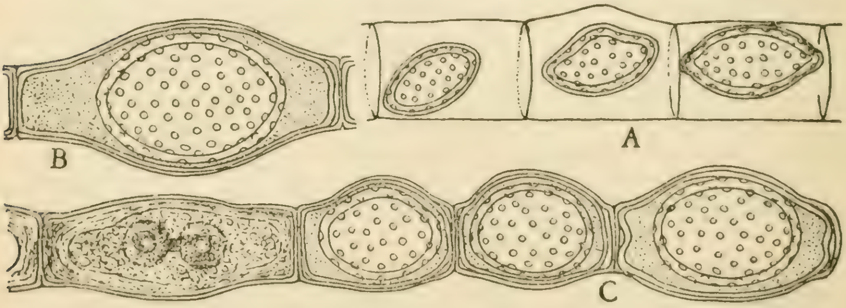


Fig. A.—*Zygnema ellipsoideum* aplanospores and sporangia. Figs. B. and C.—*Zygnema mirificum* aplanospores, immature and mature. Both figures after Jao.

94. Zygnema mirificum Jao 1947. *Bot. Bull. Acad. Sinica.* **1**, p. 97.

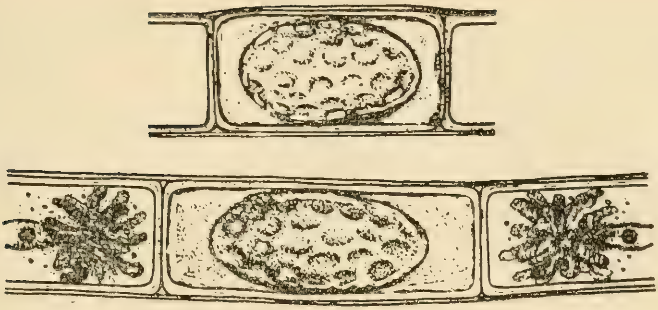
Vegetative cells 15–18μ x 25–63μ; conjugation unknown; outer aplanospore wall similar in shape and just inside the dolioform sporangium wall, 22–30μ x 30–60μ the median wall varies from ellipsoid to ovoid in the bulge of the outer wall, 20–30μ x 25–30μ. The space between the 2 walls is filled with yellowish colloidal material. The median wall is irregularly and minutely scrobiculate, yellow-brown in color.

China, Kwangsi, Suijen, June 17, 1938; in rice fields, very common.

This is a new type of *Zygnema* spore, with a colloidal layer between the outer and median walls, and the 2 walls not of the same form. It is probable, however, that the "granulose" surfaces of the median walls of certain other species result from the coagulation of a preceding colloidal layer.

95. Zygnema khannae Skuja 1949. *Nova Acta Soc. Sci. Upsali.* Ser. 4, **14**, p. 99. Pl. 22, Figs. 6–7.

Vegetative cells 24–28μ x 30–70μ, conjugation unknown; reproduc-



Figs. D and E.—*Zygnema khannae* aplanospores with outer wall cylindric, and median wall ellipsoid or ovoid. After Skuja.

tion by aplanospores, the outer wall of which is cylindric, just inside the sporangium wall, densely punctate; the median wall, formed after contraction, varies from ellipsoid to ovoid, 22–25μ x 25–46μ, yellow-brown with shallow irregular pits 1.5–5μ in diameter.

Burma, near Rangoon, 1936. (L. P. Khanna Coll.).

List of the Species of ZYGNEMA with Number

adpectinatum Transeau 1934 13
areolatum Taft & Transeau 1934 15
atrocoeruleum W. & G. S. West 1897 67
azureum Taft 1934 74
bohemicum Czurda 1932 62
borzae Krieger 1941 87
calosporum Jao 1935 48
carinatum Taft 1934 35
carinthiacum Beck 1929 75
carterae Czurda 1932 2
catenatum Transeau 1934 79
chalybeospermum Hansgirg 1888 68
chungii Li 1934 10
circumcarinatum Czurda 1930 33
coeruleum Czurda 1932 26
collinsianum Transeau 1914 70
conspicuum (Hassall) Transeau 1934 6
crassiusculum Transeau 1938 66
cruciatum (Vaucher) Agardh 1817 60
cyaneum Czurda 1932 69
cyanosporum Cleve 1868 22

CHAPTER THREE

THE GENUS ZYGNEMOPSIS (SKUJA) TRANSEAU 1934

The vegetative filaments of the 24 species here classified are usually indistinguishable from those of *Zygnema.* They may have a thin, or a thick, pectic sheath and they have been found floating in ponds, ditches, and slow flowing streams, not infrequently associated with other species of Zygnemataceae.

At the beginning of the reproductive phase, however, they may be distinguished by the partial replacement of the usual cell contents by a transparent refractive gel. Whether the cells become gametangia, or aplanosporangia, some of them lengthen and successive layers of cellulose are deposited as the protoplast contracts to the middle of the cell. At maturity the zygospores have four, and the aplanospores two, lamellate solid appendages attached to them. As seen in the illustrations, these may be short and stubby, or may be very much longer than the original vegetative cell.

All the 19 zygosporic species have isogamous gametes and scalariform conjugation. After the papillae unite in sexual reproduction the tube is exceedingly narrow, but soon broadens in the plane of the filaments. The zygospore resulting from fusion of the gametes is a compressed, more or less quadrangular pillow-shaped, body which may subsequently become lenticular or irregular in outline. Both the tube development and spore forms resemble those of the quadrangular-spored species of *Mougeotia* more than those of any species of *Zygnema.* The outer or first-formed wall bounds the colloidal gel and is composed of cellulose. The median wall is chitinous and in at least one species consists of two layers. Not infrequently yellow or brown granules are deposited between the outer and median walls and may obscure the surface features of the median wall. The innermost wall is transparent and thin and can be seen only when the spore is crushed. Parthenospores are not infrequent in some collections. They have walls similar to those of the zygospores, but are ovoid, smaller, and laterally placed in the gametangia. Aplanospores are common in 5 of the species. They vary in form from ovoid to ellipsoid and have walls similar to those of the zygospores.

When the zygospores are fully mature, an equatorial suture usually can be seen. In many collections the median wall is contracted inwardly and the surface thrown into ridges. The ridges are irregular in position and are not morphological features of the wall. They disappear when the spores are treated with dilute potassium hydroxide, while morphological features of the wall become more distinct.

The species of *Zygnemopsis* may be distinguished readily from those of *Zygnema* when in a fruiting condition by the cellulose colloid accumulation in the cells, by the initial very narrow conjugating tubes, and by the round or quadrangular pillow-shaped spores. They differ from the species of *Zygogonium* in the form of the chromatophores, the absence of cytoplasmic residues in the gametangia and sporiferous cells, in the form of the spores, and in the stages of tube formation. From the species of *Debarya* they may be distinguished by the *Zygnema*-like chromatophores; and from *Hallasia* by the absence of aplanospores from which one, two, or three sporelings develop.

Some of the species here classified in the genus *Zygnemopsis* have been previously placed in the genera: *Debarya, Mougeotia,* and *Zygnema.*

Key to the Species of ZYGNEMOPSIS

1\. Reproducing by aplanospores.............................. 12
1\. Reproducing by zygospores, sometimes aplanospores also..... 2
  2. Diameter vegetative cells mostly less than 8 μ............ 3
  2. Diameter vegetative cells mostly between 8 and 16 μ...... 4
  2. Diameter vegetative cells mostly 16 μ or more............ 11
3\. Median spore wall punctate, yellow, diameter vegetative cells 4–6 μ........ 1. *Z. sikangensis*
3\. Median spore wall smooth, golden-brown, diameter vegetative cells 6–7 μ 2. *Z. orientalis*
3\. Median spore wall scrobiculate, yellow, diameter vegetative cells 6–8 μ........ 4. *Z. floridana*
  4. Shorter axis of zygospores less than 32 μ................ 5
  4. Shorter axis of zygospores 32 μ or more.................. 8
5\. Diameter vegetative cells mostly less than 12 μ............... 6
5\. Diameter vegetative cells mostly more than 12 μ............. 7
  6. Median spore wall smooth, chocolate brown .... 5. *Z. minuta*

6. Median spore wall punctate, yellow-brown .... 6. *Z. desmidioides*
6. Median spore wall punctate, chestnut brown .... 7. *Z. columbiana*
6. Median spore wall punctate, yellow 9. *Z. tiffaniana*
6. Median spore wall scrobiculate, yellow .... 10. *Z. sinensis*
6. Median spore wall finely scrobiculate, yellow-brown .... 8. *Z. americana*

7. Median spore wall scrobiculate, yellow, pits 2–3 μ .... 10. *Z. sinensis*
7. Median spore wall scrobiculate, yellow-brown, granulose .... 12. *Z. splendens*

8. Median spore wall punctate, or undulate, granulose .... 15. *Z. iyengarii*
8. Median spore wall punctate, chocolate brown .... 17. *Z. sphaerospora*
8. Median spore wall scrobiculate.......................... 9

9. Zygospores 32–36 μ x 36–42 μ, golden yellow, suture .... 14. *Z. stephensiae*
9. Zygospores with shorter axis more than 36 μ................. 10

10. Median spore wall smooth or undulate, yellow-brown, granulose..... 11. *Z. indica*
10. Median spore wall deeply scrobiculate, pits 2–4 μ angular........... 13. *Z. wuchangensis*
10. Median spore wall scrobiculate, pits 3 μ round .... 16. *Z. quadrata*

11. Zygospores 36–52 μ, brown to green... 18. *Z. lamellata*
11. Zygospores 24–30 μ x 30–48 μ, brown... 20. *Z. decussata*
11. Zygospores 28–36 μ x 48–60 μ, brown... 21. *Z. spiralis*

12. Vegetative cell diameter 8 μ or less 3. *Z. gracilis*
12. Vegetative cell diameter 14–22 μ.......................... 13
12. Vegetative cell diameter 30–50 μ.......................... 14

13. Spores spindle-shaped, median wall scrobiculate .... 19. *Z. transeauiana*
13. Spores ovoid, truncate, median wall scrobiculate .... 20. *Z. decussata*
13. Spores compressed-ovoid, tricarinate.. 22. *Z. fertilis*

14. Spores ellipsoid to ovoid, diameter 40–55 μ .... 24. *Z. hodgettsii*
14. Spores ellipsoid to ovoid, diameter 70–94 μ .... 23. *Z. pectinata*

Descriptions of Species

1. Zygnemopsis sikangensis Li 1939. *Bull. Fan Mem. Inst. Biol., Botany.* **9**, p. 225.

Vegetative cells 4–6μ x 38–68μ, each with 2, sometimes 4, chromatophores; conjugation scalariform; zygospores quadrangular-ovoid, 18–22μ x 18–22μ, filling the tube and extending into the gametangia; median spore wall yellow and punctate. (Pl. VIII, Figs. 1–2.)

China, Sikang, Yünnan.

2. Zygnemopsis orientalis (Carter) Transeau 1944. *Ohio Jour. Sci.* **44**, p. 244. *Records Bot. Surv. India.* **9**, p. 281. 1926 (as *Debarya desmidioides* var. *orientale* Carter).

Vegetative cells 6–7μ x 30–67μ; conjugation scalariform; zygospores quadrangular, pillow-form, 20–25μ on a side, filling the broad tubes and dividing the gametangia; median spore wall golden-brown, whether smooth or punctate not stated. (Pl. VIII, Figs. 3–5.)

India, Matiana on the Tibetan road from Simla, altitude 8,500 feet, April 30, 1907.

3. Zygnemopsis gracilis Randhawa 1938. *Proc. Indian Acad. Sci.* **8**, p. 133, Fig. 18.

Vegetative cells 6–7μ x 40–70μ; reproduction by aplanospores formed in spindle-shaped sporangia, with spores in the median region; spores globose to ovoid, about 20μ in diameter; color and markings on the median wall undetermined. (Pl. VIII, Figs. 6–7.)

India, Makrahi, Fyzabad, U.P., March 12, 1938.

4. Zygnemopsis floridana Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 215, Pl. 18, Fig. 20.

Vegetative cells 7–8μ x 30–40(–50)μ; chromatophores 2, pillow-form, each with a pyrenoid; conjugation scalariform; zygospores formed in the greatly enlarged conjugating tubes and extending but little into the gametangia which lengthen during conjugation to 50–90μ; spores ovoid to quadrate-ovoid, 18–25μ x 28–30μ; median spore wall bright yellow, scrobiculate; pits 2–3μ in diameter and about the same distance apart. (Pl. VIII, Figs. 8–9.)

United States: Florida, Fort Myers, May 25, 1933 (Blaydes Coll.).

5. Zygnemopsis minuta Randhawa 1937. *Proc. Indian Acad. Sci.* **5**, p. 312, Fig. 8.

Vegetative cells 8–12μ x 30–70μ, each with 2 compressed-ovoid chromatophores; conjugation scalariform, dissociation occurring during or after conjugation; zygospores globose to quadrate-globose,

22–25μ x 25–30μ; outer spore wall hyaline; median wall thick, chocolate brown, smooth; aplanospores more abundant than zygospores, asymmetrically ovoid to globose, sometimes with the 2 ends slightly produced, 18–20μ x 18–31μ. (Pl. VIII, Figs. 10–11.)

United States: Michigan, Douglas Lake region (Taft Coll.).

India, Fyzabad, U.P., March, 1937.

6. Zygnemopsis desmidioides (W. & G. S. West) Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 215, Fig. 25.

Vegetative cells 8–11μ x 19–56μ, constricted at the ends; chromatophore an axial plate with 2 pyrenoids; filaments fragment readily; "conjugation between free cells" scalariform; zygospores formed in the broad conjugating tubes and extending somewhat into both gametangia; spores quadrangular with straight, concave, or slightly convex sides and rounded angles, 14–18μ x 18–24μ; median spore wall golden-brown, thick, finely punctate. (Pl. VIII, Figs. 12–14.)

United States: Wisconsin.

England; Latvia.

The statement by West that conjugation takes place between free cells is probably incorrect. Fragmentation of filaments occurs during and after conjugation in several other species. The filaments of *Z. desmidioides* have a pectic sheath. When conjugation occurs this sheath passes into solution and, as the gametangia become distended with pectic compounds, the ends become rounded and separate.

7. Zygnemopsis columbiana Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 215, Figs. 27–29.

Vegetative cells (8–) 9.5–11.5μ x 40–100μ, with 2 pillow-shaped chromatophores, each with a central pyrenoid; conjugation scalariform; zygospores formed in the wide conjugating tubes and extending far into each gametangium; spores quadrate-ovoid, 23–32μ x 23–34μ, with angles rounded, produced, or retuse; median spore wall with a prominent suture, finely punctate, chestnut brown; aplanospores ellipsoid to ovoid, 18–20μ x 25–30μ, otherwise similar. (Pl. VIII, Figs. 15–17.)

Canada, British Columbia (W. R. Taylor Coll.).

8. Zygnemopsis americana Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 215.

Vegetative cells 9–12μ x 27–100μ; 2 compressed-ovoid chromatophores; conjugation scalariform; zygospores formed in the broad conjugating tubes and extending far into both gametangia; spores ovoid to quadrate-ovoid, 20–40μ x 30–40μ; parthenospores 15–20μ x 20–30μ, unilaterally ellipsoid with retuse ends; median spore wall minutely

scrobiculate, usually hidden by layer of yellow-brown granules between the outer and median walls. (Pl. VIII, Figs. 18–21.)

United States: Michigan, Douglas Lake region; Wisconsin, Madison. Canada, Ontario (A. B. Klugh Coll.).

9. Zygnemopsis tiffaniana Transeau 1944. *Ohio Jour. Sci.* **44**, p. 244. Formerly listed as *Debarya cruciata* and *Z. cruciata* Price (1911).

Vegetative cells 10–12μ x 30–60μ; chromatophore with 2 pyrenoids; conjugation scalariform; zygospores formed in the broad conjugating tubes and extending into both gametangia; spores quadrangular with concave or rarely straight sides, angles produced or slightly concave, 20–24μ x 28–32μ; median spore wall yellow, punctate. (Pl. VIII, Figs. 22–23.)

United States: Florida (Tiffany Coll.); Oklahoma (Taft Coll.).

Canada, British Columbia (Wailes Coll.).

Named for Hanford L. Tiffany of Northwestern University, author of *The Oedogoniaceae* and *Algae, the Grass of many Waters.*

In 1932 there was but one incompletely described species with approximately these dimensions. Now there are several with mature spores and it is impossible to say which species Price had in 1911. The American collections are clearly representatives of a single species, and not necessarily "Z. cruciata."

10. Zygnemopsis sinensis Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 215, Fig. 22.

Vegetative cells 10–13μ x 29–72μ, with 2 more or less elongate, stellate chromatophores; conjugation scalariform; zygospores formed in the broad conjugating tubes and extending far into both gametangia; spores quadrate-ovoid, 29–32μ x 29–36μ; median spore wall yellow, scrobiculate; pits 2–2.5μ in diameter, 2.5–3μ apart. (Pl. VIII, Fig. 24.)

China, Wuchang, Hupeh (Li Coll.).

11. Zygnemopsis indica Randhawa 1937. *Proc. Indian Acad. Sci.* **5**, p. 297, Fig. 1. Also as *Ghosella indica.* 1934.

Vegetative cells 10–15μ x 50–75μ, with 2 rounded or stellate chromatophores, each with a central pyrenoid; reproduction by zygospores, parthenospores, and aplanospores; conjugation scalariform; zygospores compressed-quadrangular-ovoid or compressed-globose, 34–46μ x 40–53μ; median wall yellow-brown, smooth or undulate, with abundant granules between the outer and median walls; aplanospores and parthenospores with similar walls, 20–26μ x 40–46μ, in sporangia to 80μ in length. (Pl. VIII, Figs. 26–27.)

India, Punjab near Hamira, February to April, 1930.

12. Zygnemopsis splendens Randhawa 1937. *Proc. Indian Acad. Sci.* 5, p. 297, Fig. 2.

Vegetative cells 12–15μ x 30–42μ, with 2 more or less rounded chromatophores; conjugation scalariform; zygospores varying from compressed-ovoid to quadrangular-ovoid, 26–30μ x 40–50μ; outer wall blue, median wall yellow-brown, scrobiculate with pits 1–2μ in diameter; often a layer of brownish granules between the outer and median walls. (Pl. VIII, Fig. 25.)

India, Fyzabad, U.P., January to March, 1937.

13. Zygnemopsis wuchangensis Li 1937. *Bull. Fan Mem. Inst. Biol., Botany.* 8, p. 18.

Vegetative cells 12–15μ x 32–84μ, each with 2 stellate chromatophores; conjugation scalariform; zygospores quadrangular-ovoid, 36–56μ x 42–64μ x 28–35μ in thickness; median spore wall yellow, angularly scrobiculate, with very deep distinct pits, 2–4μ in diameter, and with a distinct suture. (Pl. VIII, Figs. 28–29.)

China, Wuchang, Hupeh.

14. Zygnemopsis stephensiae Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 215, Fig. 21.

Vegetative cells 12–15μ x 36–60μ, with 2 more or less stellate chromatophores; conjugation scalariform; zygospores formed in the greatly enlarged conjugating tubes and extending into both gametangia, which are otherwise filled with pectic-cellulose material; spores quadrately ovoid, 32–36μ x 36–42μ; with angles rounded or truncate, and sides straight or concave; median spore wall yellow, irregularly scrobiculate, pits about 2–4μ in size. (Pl. IX, Fig. 1.)

South Africa, Cape Colony (Stephens Coll.).

15. Zygnemopsis iyengarii Randhawa 1937. *Proc. Indian Acad. Sci.* 5, pp. 306–8, Figs. 5–6.

Vegetative cells 12–16μ x 60–120μ, with 2 more or less rounded chromatophores in each cell; conjugation scalariform; zygospores formed in the greatly distended tube and extending into the gametangia; zygospores compressed-globose to ovoid, 38–54μ in diameter, with a thick outer blue wall, a smooth or undulate yellow-brown median wall, which is variously wrinkled by unequal contraction; with a few or many granules between the walls; aplanospores ovoid to spindle-shaped, 24–28μ in diameter, with similar walls. (Pl. IX, Figs. 2–3.)

India, Fyzabad, U.P., January, 1937.

On shrunken spores there are ridges, variously disposed, which disappear when a dilute potassium hydroxide solution is applied.

16. Zygnemopsis quadrata Jao 1935. *Sinensia.* 6, p. 573, Pl. 2, Figs. 26–30.

Vegetative cells 13–16 μ x 29–71 μ; 2 (rarely 3 or 4) chromatophores; conjugation scalariform; fertile cells slightly geniculate; zygospores in the conjugating tubes often extending into the gametangia; zygospores compressed-ovoid to quadrangular-ovoid, 38–48 μ x 45–60 μ x 29–32 μ; outer wall smooth, transparent, usually remote from the median layer; median layer golden yellow, scrobiculate; pits about 3 μ in diameter, 1.5–2.5 μ apart, suture prominent. (Pl. IX, Figs. 4–5.)

China, Szechwan, rice farms and pools.

17. Zygnemopsis sphaerospora Randhawa 1938. *Proc. Indian Acad. Sci.* 8, p. 131, Fig. 16.

Vegetative cells 14–16 μ x 45–50 μ, with 2 chromatophores; reproduction by zygospores; conjugation scalariform; zygospores compressed-globose, 34–38 μ in diameter; median spore wall chocolate brown, punctate; pits about .5 μ in diameter. (Pl. IX, Figs. 6–7.)

India, Fyzabad, U.P., May, 1938.

18. Zygnemopsis lamellata Randhawa 1937. *Proc. Indian Acad. Sci.* 5, p. 302, Figs. 3–4.

Vegetative cells 13–18 μ x 32–52 μ, with 2 stellate chromatophores; reproduction by zygospores; conjugation scalariform, some gametangia lengthening to 98 μ; zygospores usually compressed, quadrately ovoid, sometimes compressed-globose; sporangia with thick, lamellate walls; zygospores 36–48 μ x 36–52 μ; outer wall transparent; median wall of 2 layers, of which the outer is blue and undulate at full maturity, and the inner finely scrobiculate, yellow to brown in color. Sometimes there are also yellow granules between the walls. (Pl. IX, Figs. 8–9.)

India, Fyzabad, U.P., February to April, 1937.

19. Zygnemopsis transeauiana Randhawa 1938. *Proc. Indian Acad. Sci.* 8, p. 132, Fig. 17.

Vegetative cells 14–18 μ x 25–50 μ, with 2 chromatophores more or less rounded and near the middle of the cell, regardless of its length; reproduction by aplanospores. During the development of the sporangium the cells may elongate to 90–144 μ and increase in thickness to 19 μ. As the protoplast contracts, pectic compounds and cellulose accumulate, and the middle of the sporangium enlarges in diameter (up to 35 μ). The outer spore wall is colorless and adherent to the pectic gel. Between this wall and the median wall yellow or brown granules may accumulate. The median wall is ovoid to compressed-globose, 16–25 μ x

23–50μ, with a more or less prominent suture, yellow and scrobiculate, with pits 2–3μ in diameter. (Pl. IX, Figs. 10–11.)

India, Fyzabad, U.P., February to April.

20. ZYGNEMOPSIS DECUSSATA Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 214. Includes *Zygnema pseudodecussatum* Czurda 1932.

Vegetative cells 16–20μ x 24–50μ; chromatophores as in *Zygnema,* each with 1 pyrenoid; conjugation scalariform; zygospores extending far into each gametangium, ovoid to quadrate-ovoid, and irregular, 24–30μ x 30–48μ, the angles rounded, retuse, or produced; aplanospores unilaterally ovoid, the plane of the convex side changing in successive cells, 17–25μ x 20–40μ; parthenospores 15–20μ x 20–30μ; median wall in all the spores scrobiculate; akinetes with smooth, heavy walls, 18–20μ x 20–36μ. (Pl. IX, Figs. 12–15.)

United States: Oklahoma; Iowa; Arkansas; Illinois; Kentucky; Michigan.

Canada, Ontario; Europe, Bohemia; China, Szechwan.

Some collections have only aplanospores, others only scalariform conjugation and zygospores, still others have filaments with both zygospores and aplanospores. In Illinois the size of the filaments was regularly 18–20μ in diameter, but I have a collection sent me by Dr. Li from Amoy, China, in which some of the conjugating filaments have diameters as low as 12μ. The zygospores, however, are of the usual dimensions.

21. ZYGNEMOPSIS SPIRALIS (Fritsch) Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 214.

Vegetative cells 18–25μ x 26–60μ, with 2 stellate chromatophores; conjugation scalariform; gametangia sometimes elongating to 130μ; zygospores quadrately ovoid, 28–36μ x 48–56μ; outer wall thin or thick, transparent, usually separated from the median wall and sometimes covered internally with granules; median wall punctate or finely scrobiculate. (Pl. IX, Fig. 16.)

United States: Wisconsin; Michigan (Prescott Coll.).

South Africa, Table Mountain, wet rock on slope, July 19, 1908; Latvia (Skuja Coll.).

22. ZYGNEMOPSIS FERTILIS (Fritsch & Rich) Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 216.

Vegetative cells 20–22μ in diameter; slight constrictions between the cells; chromatophores 2, stellate; zygospores unknown; sporogenous cells distended in the center; aplanospores compressed-ovoid, 31–32μ x 41–49μ; median spore wall with 3 (or more) longitudinal ridges; spores immature. (Pl. IX, Fig. 17.)

South Africa.

23. Zygnemopsis pectinata (Fritsch) Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 216. *Ohio Jour. Sci.* 25, p. 198, Figs. 38–44. 1925.

Vegetative cells 36–42μ x 83–200μ; chromatophores 2, stellate or elongated stellate, each with a pyrenoid or rarely 2 or 3 pyrenoids; zygospores unknown; akinetes swollen toward the middle to 80μ, with walls 6–8μ thick, sometimes obliquely ventricose, alternating in successive cells; aplanospores ellipsoid, or with polar thickenings, 70–94μ x 100–128μ; outer spore wall 4–8μ thick, smooth; median spore wall irregularly granulose. (Pl. IX, Figs. 18–21.)

South Africa, Kentani District.

The specimens upon which this description is based have an amazing variety of chromatophores only illustrated in part in the publication of 1925. None of the spores examined is believed to be fully mature.

24. Zygnemopsis hodgettsii Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 216. Hodgetts. *Trans. Roy. Soc. S. Africa.* 13, p. 67. 1925.

Vegetative cells 35–50μ x 20–75μ in diameter, with 2 stellate chromatophores; zygospores unknown; aplanospores ovoid, 40–55μ x 65–80μ, immature. (Pl. IX, Fig. 22.)

South Africa, Stellenbosch.

This and the 2 preceding species are obviously imperfectly described species, but have characteristics that clearly place them in this genus, and not in the genus *Zygnema*.

List of the Species of ZYGNEMOPSIS with Number

CHAPTER FOUR

THE GENUS HALLASIA ROSENVINGE 1924

Among the incompletely known genera of the Zygnemataceae is *Hallasia,* proposed by Rosenvinge in 1924 better to classify the *Zygnema reticulatum* described by Emma Hallas in 1895. The young vegetative cells resemble those of *Zygnema* in having two stellate chromatophores, but at the beginning of spore formation there may be an increase in the number of chromatophores up to seven. At the same time the cells may elongate, and as the cell contents contract toward the enlarged middle portion the cell cavity becomes filled with a cellulose-pectose colloid as in *Zygnemopsis.* The aplanospores also resemble those of *Zygnemopsis* in being ellipsoid. When these aplanospores germinate, however, there may emerge one, two, or three sporelings. This Rosenvinge interprets as analogous to the germination of parthenospores in *Cosmarium* from which two sporelings result. He has suggested that the genus be placed among the Mesotaeniaceae or between that family and the Zygnemataceae.

The species has previously been classified in *Zygnema* Hallas 1895, in *Debarya* Transeau 1925, and in *Zygnemopsis* Transeau 1934.

Description of Species

Hallasia reticulata Rosenvinge 1924. *Rev. Algolog.* **1**, pp. 209–12. Hallas. *Bot. Tidsskrift.* **20**, pp. 1–16. 1895 (as *Zygnema reticulatum*).

Vegetative cells 18–20μ x 35–100μ with 2 to 7 stellate chromatophores in each cell; reproduction by aplanospores which are ellipsoid and up to 35μ in diameter, 60μ long; median spore wall yellow, scrobiculate or irregularly reticulate; sporogenous cells lengthen up to 240μ. At germination the contents of the spores may become divided into 2 or 3 parts, from each of which a new filament develops. Sometimes only a single plant develops from a spore. (Pl. X, Figs. 1–9.)

Denmark, Copenhagen.

According to Rosenvinge the plant has not been found again at the site of the original collection.

CHAPTER FIVE

THE GENUS ZYGOGONIUM KÜTZING 1843

The discovery and description of 14 species belonging to this genus have demonstrated the distinctive characteristics of the genus clearly and have justified its separation from the genus *Zygnema*. The small pillow-shaped, or compressed-globular, chromatophores of the *Zygogoniums* are quite different from those of the *Zygnemas*. Under certain conditions these chromatophores may have a few short irregular appendages. In all species that have been described, however, the chromatophores occupy but a small fraction of the cell lumen. The small nucleus lies in the bridge between the chromatophores.

The filaments are often branched, sometimes with horizontal branches and rhizoids in the soil surface, and with erect branches arising from them. A regular feature of the species growing on soil is the formation of thick, lamellate vegetative cell walls and akinetes. Indeed in situations which frequently are dry, the filaments appear to be chains of akinetes.

A common mode of reproduction is by aplanospores. These globose or cylindric-ovoid spores are formed within vegetative cell walls and are usually much smaller than the cells. Cytoplasmic residues are present regularly in the cell lumen outside the spore, a feature not found in *Zygnema*.

Reproduction by zygospores is less frequently seen. Conjugation may be scalariform or lateral. In either event there are cytoplasmic residues left in the gametangia after the union of the gametes. All the 14 species that have been found reproducing sexually have the zygospores in sporangia formed by the greatly enlarged conjugating tubes. The two gametes unite directly in the tube, and a sporangium wall is immediately formed around them which separates them from the gametangia. The spores are discharged by the breaking of a distinct equatorial suture in the sporangium wall.

All the species are amphibious and grow on wet, acid mineral

soils, rocks, and bogs. From there they are sometimes carried into streams and ditches by rains, and continue to grow in the water medium.

In *Zygogonium ericetorum* there is a strong tendency toward encystment whenever habitat conditions change; this is true even of the gametes. The gametes may be walled off in the conjugating papillae before the solution of the wall between the papillae. Subsequently this wall may be dissolved and the gametes may unite. This was the mode of reproduction first seen and described by de Bary (1858). Subsequently normal reproduction was described by the Wests (1894), but in 1918 Hodgetts found and described the reproduction by encysted gametes and insisted that this is the normal process. In 1933 Transeau published figures showing both modes of conjugation in the same pairs of filaments. Since none of the other species exhibits so-called secondary gametangia, these must be regarded as a peculiarity of *Z. ericetorum,* and direct conjugation the normal procedure.

The taxonomic characteristics of the genus *Zygogonium* may be summarized as follows:

1. The species are terrestrial or amphibious on acid substrates.

2. The filaments may become branched, sometimes with horizontal filaments on the soil and erect branches arising from them.

3. Reproduction by akinetes and aplanospores is common. All the vegetative cells of some filaments may be changed to these structures.

4. Reproduction by zygospores is apparently infrequent, and the zygospores are enclosed in a sporangium wall with an equatorial suture.

5. Cytoplasmic residues are present in sporiferous and gametangial cells after spore formation.

6. Cell walls and cell contents are often colored purple, and in terrestrial specimens the cell walls may become very thick, opaque, and yellow or brown.

7. Accumulation of fat globules and starch in terrestrial specimens often obscures both the nucleus and the chromatophores.

Key to the Species of ZYGOGONIUM

1. With aplanospores only (zygospores unknown) 7
1. With zygospores (sometimes aplanospores also) 2
   2. Median spore wall smooth 3
   2. Median spore wall not smooth, yellow to brown 4
   2. Median spore wall not smooth, blue 13. *Z. indicum*

3. Zygospores 15–26 μ x 20–36 μ, sporangium suture indistinct.................. 1. *Z. ericetorum*
3. Zygospores 13–17 μ x 19–32 μ, sporangium suture prominent................ 2. *Z. mirabile*
3. Zygospores 20–25 μ x 18–25 μ, sporangium with pectic wall................. 3. *Z. pectosum*
4. Zygospore median wall scrobiculate or punctate.......... 5
4. Zygospore median wall with pits, or marginal arched ridges 6
5. Zygospores without distinct suture, median wall punctate.................... 8. *Z. punctatum*
5. Zygospores without distinct suture.... 9. *Z. heydrichii*
5. Zygospores in sporangia having collars at both ends.......................... 14. *Z. stephensiae*
5. Zygospores with distinct suture....... 10. *Z. sinense*
6. Zygospores with scattered pits on median wall .... 11. *Z. exuvielliforme*
6. Zygospores with arching ribs on one side of suture................ 12. *Z. plakountiosporum*
7. Spore walls probably smooth at maturity.................... 8
7. Spore walls not smooth when mature....................... 9
8. Diameter vegetative cells 10–14 μ, spores usually terminal........... 7. *Z. kumaoënse*
8. Diameter vegetative cells 12–20 μ, spores usually lateral............. 5. *Z. talguppense*
9. Diameter vegetative cells 8–12 μ, spore wall verrucose .... 4. *Z. hansgirgii*
9. Diameter vegetative cells 16–20 μ, spore wall scrobiculate .... 6. *Z. capense*

Descriptions of Species

1. Zygogonium ericetorum Kützing 1843. *Phycologia Generalis*, p. 446.

Vegetative cells 12–33 μ x 10–100 μ; chromatophores 2, stellate, pillow-form or indefinite, each with a central pyrenoid; filaments branched or unbranched; conjugation scalariform. Zygospores develop within definite sporangia formed by the conjugating tubes and cut off by a wall from the adjoining gametangia. Zygospores ovoid or ellipsoid, 15–26 μ x 20–36 μ, thick-walled, smooth; aplanospores globose or ovoid, occupying only a part of the original cell, 15–20 μ x 15–40 μ; wall smooth. (Pl. X, Figs. 10–16.)

United States: Known to occur on acid soils, in ponds and peat bogs throughout the coastal plain from Maine to Mississippi, and in Ohio, Mich-

igan, Colorado, and Utah. Also in Canada from western Ontario to Nova Scotia. Probably occurs throughout the northern and western provinces.

Reported from all the continents.

In terrestrial forms the cell sap may be purple, the cells somewhat smaller, and the walls thick, lamellate, and colored yellow or brown. In a collection from Kwangtung, China, the sporangia had a distinct outer pectic layer.

2. Zygogonium mirabile (W. & G. S. West) Transeau 1933. *Ohio Jour. Sci.* **33**, p. 158. *Jour. Bot.* **35**, p. 39. 1897.

Vegetative cells 12–13.5 μ x 18–50 μ; chromatophores 2, rather indistinct, each with a central pyrenoid; conjugation scalariform; zygospores formed in the enlarged conjugating tubes, which are walled off from the original cells; sporangium ovoid with prominent equatorial suture; spores filling the sporangium, ovoid, 13.5–17 μ x 19–32 μ, smooth, but possibly immature in the one known collection. (Pl. X, Figs. 17–19.)

Portuguese West Africa, Huilla, April, 1860 (Welwitsch Coll.).

3. Zygogonium pectosum Taft 1944. *Ohio Jour. Sci.* **44**, p. 238.

Vegetative cells 9–12 μ x 12–108 μ, with 2 pillow-shaped chromatophores, sometimes elongate with flat ends; conjugation scalariform and lateral; zygospores formed in the greatly enlarged tubes; zygospores globose or subglobose (15–) 20–25 μ x 18–25 μ, with a smooth, slate-blue wall; aplanospores cylindric-ovoid, 9–10 μ x 12–16 μ, also slate-blue; sporangium outer wall a 2–4 μ layer of pectic compound. During conjugation the cells elongate and the walls change to pectic compounds and become greatly thickened. (Pl. XI, Figs. 1–3.)

United States: Louisiana, near Hornbeck on wet seepage slopes, April, 1940.

4. Zygogonium hansgirgii (Schmidle) Transeau 1933. *Ohio Jour. Sci.* **33**, p. 159. *Hedwigia.* **39**, p. 160. 1900 (as *Zygnema hansgirgii*).

Vegetative cells 8–12 μ x 30–60 μ, irregular; filaments short; conjugation unknown; aplanospore variable, ovoid, about the same diameter as the cells; median wall brown, with small angular protuberances (verrucose). (Pl. XI, Figs. 4–6.)

India, Igatpuri, 1895.

5. Zygogonium talguppense Iyengar 1932. *Rev. Algolog.* **6**, pp. 263–74.

Filaments forming a thick felt on soil, increasing in width upwards, often branching below; lower cells of the filament 12–16 μ x 30–60 μ, the upper 17–20 μ x 30–90 μ; conjugation unknown; aplan-

ospores ellipsoid to subglobose, 12–26μ x 13–34μ, developed in a lateral swelling and cut off from the parent cell by a curved wall; median spore wall smooth. (Pl. XI, Figs. 7–8.)

India, Mysore, on moist soil in plantation of Areca palm.

6. Zygogonium capense (Hodgetts) Transeau 1933. *Ohio Jour. Sci.* **33**, p. 159. *Trans. Roy. Soc. S. Africa.* **13**, p. 66. 1925 (as *Zygnema capense*).

Vegetative cells 16–20μ x 20–60μ; conjugation unknown; aplanospores globose, 19–26μ in diameter, formed at the ends of the cells; median spore wall brown, scrobiculate. (Pl. XI, Figs. 9–11.)

South Africa, Stellenbosch, on damp soil.

7. Zygogonium kumaoense Randhawa 1940. *Jour. Indian Bot. Soc.* **19**, p. 247.

Filaments forming a feltlike growth on clay soil, prostrate filaments of irregular cells with rhizoids, upright filaments of cylindrical cells with elongated chromatophores and sometimes very long cells; vegetative cells, 10–14μ x 20–140μ; reproduction by aplanospores, globose to subglobose, 12–16μ x 15–24μ, with transparent, smooth walls. (Pl. XI, Figs. 16–19.)

India, Kumaon Himalayas, September, 1939.

8. Zygogonium punctatum Taft 1944. *Ohio Jour. Sci.* **44**, p. 238.

Vegetative cells 9–12μ x 30–45μ, with 2 small, irregularly globose chromatophores; conjugation scalariform between gametangia that have elongated up to 115μ; zygospores globose or subglobose, 18–27μ x 21–32μ, enclosed by a distinct sporangium wall; median spore wall yellow to yellow-brown, punctate. (Pl. XI, Fig. 12.)

United States: Louisiana, De Ridder, on roadside seepage slopes, April, 1940.

9. Zygogonium heydrichii (Schmidle) Transeau 1933. *Ohio Jour. Sci.* **33**, p. 159. *Flora.* **83**, p. 167. 1897 (as *Zygnema heydrichii*).

Vegetative cells 14–20μ x 25–80μ, with 2 chromatophores, not stellate; conjugation lateral or scalariform; tubes arise from both gametangia and form sporangia walled off from the original cells; zygospores globose, ovoid, or kidney-shaped, 22–28μ x 30–36μ; median spore wall yellow, scrobiculate. (Pl. XI, Figs. 13–15.)

Australia, Sydney.

10. Zygogonium sinense Jao 1935. *Sinensia.* **6**, p. 571.

Vegetative cells 16–17μ x 38–64μ; chromatophores 2, irregularly

globose bodies; reproduction by zygospores and parthenospores enclosed by sporangial walls; conjugation scalariform and lateral; zygospores compressed-globose or subglobose, 29–38μ x 22–25μ; median spore wall yellow to brown, sharply scrobiculate on the faces, only slightly scrobiculate or striate near the prominent equatorial suture; parthenospores without prominent suture. (Pl. XII, Figs. 1–5.)

China, Nanking and Chungking.

11. Zygogonium exuvielliforme Jao 1935. *Amer. Jour. Bot.* 22, p. 768.

Vegetative cells 13–22μ x 48–105μ; chromatophores 2; conjugation lateral and scalariform; spores formed in the greatly enlarged conjugating tubes; zygospores compressed-globose with distinct or prominent sutures, 35–42μ x 38–54μ in diameter; median wall yellow to brown, thick, lamellate, with scattered pits except near the equatorial suture. (Pl. XII, Figs. 6–8.)

South America, Colombia, Lake Macotama at 14,400 feet altitude.

12. Zygogonium plakountiosporum Jao 1935. *Amer. Jour. Bot.* 22, p. 767.

Vegetative cells 16–22μ x 30–155μ, with 2 chromatophores close to the nucleus; conjugation lateral and scalariform; tubes greatly distended containing the spores; zygospores compressed-globose with colorless outer wall; median wall brown, with equatorial suture more or less prominent, and with arching ridges forming a zone of pits on one side of the suture; spore dimensions 35–41μ x 40–68μ x 14–20μ. (Pl. XII, Figs. 9–11.)

South America, Colombia, Lake Macotama at 14,400 feet altitude.

This species is remarkable for its asymmetrically ornamented spores.

13. Zygogonium indicum (Randhawa) Transeau. nom. nov. *Proc. Indian Acad. Sci.* 8, p. 140 (as *Zygnema heydrichii* var. *indicum* Randh.).

Vegetative cells 18–22μ x 50–90μ, with 2 chromatophores near the nucleus; conjugation usually lateral, rarely scalariform; zygospores ovoid 22–27μ x 31–37μ; median wall greenish-blue to dark blue; scrobiculate with pits about 2μ in diameter; parthenospores smaller and similar.

India, Fyzabad, U.P., March 12, 1938.

This species is placed in the genus *Zygogonium* because the spore is separated from the gametangia by a wall. In appearance it resembles *Zygogonium heydrichii,* a species having yellow spores.

14. Zygogonium stephensiae nom. nov. *Trans. Amer. Micros. Soc.* 53, p. 208, Pl. 17, Fig. 4. 1934 (as *Zygnema stephensiae* Transeau).

Vegetative cells 22–29μ x 60–120 (–160) μ; conjugation scalariform; zygospores in the tubes, mostly globose 37–46μ in diameter, or ovoid 32–43μ x 46–54μ; median spore wall yellow-brown, densely punctate. The sporangium wall is of 2 layers—the outer is the tube wall and the inner is formed immediately after union of the gametes and completely encloses the spore. The polar ends of the outer wall are of cellulose; the middle part is of pectose. At maturity the pectose part may change to pectic acid and disappear, and leave a collar at each pole of the sporangium. The inner wall has an equatorial suture and the spore is released by separation of the 2 hemispheres at this suture. The empty hemispheres remain attached to the gametangial wall. (Pl. XLI, Figs. 1–5.)

United States: Pennsylvania, Roaring Branch, on wet sandstone cliffs, September 21, 1933.

Africa, Cape Colony, Cape Flats (E. Stephens Coll.), November 24, 1927.

Cylindric akinetes make up entire filaments in one of the collections. Akinetes have a length about equal to the diameter of the filament.

List of Species of ZYGOGONIUM with Numbers

capense (Hodgetts) Transeau 1933 6
ericetorum Kützing 1843 1
exuvielliforme Jao 1935 11
hansgirgii (Schmidle) Transeau 1933 4
heydrichii (Schmidle) Transeau 1933 9
indicum (Randhawa) Transeau 1951 13
kumaoënse Randhawa 1940 7
mirabile (W. & G. S. West) Transeau 1933 2
pectosum Taft 1944 3
plakountiosporum Jao 1935 12
punctatum Taft 1944 8
sinense Jao 1935 10
stephensiae Transeau 1951 14
talguppense Iyengar 1932 5

CHAPTER SIX

THE GENUS PLEURODISCUS LAGERHEIM 1895

This genus was established by Lagerheim to classify purple-colored vegetative filaments, the cells of which had two distinct disc-shaped chromatophores, one on either side of a central nucleus *(P. purpureus).* Skuja (1932) questioned the validity of the genus and suggested that the chromatophore is merely an expanded form of the *Zygogonium* chromatophore due to environmental conditions. In 1936 Tiffany described a species *P. borinquenae* from Puerto Rico, the first and only specimens found in a fruiting condition. The chromatophores certainly were disc-shaped and oriented at various angles to each other. The processes of conjugation and spore formation resemble those of *Zygogonium.*

Specimens resembling Lagerheim's figure, collected near Eaglesmere, Pennsylvania, and those collected by Randhawa in India, were associated with smaller vegetative filaments of *Zygogonium*; there were no intergradations. Environmental factors do not seem to account for the differences in chromatophores in these collections. When *Zygogonium* filaments are growing luxuriantly, the pillow-shaped chromatophores are larger and there is a fringe of several stringlike or radial projections, very different from the smooth-edged disc, or saucer-shaped, bodies of *Pleurodiscus.* Further study of the algae growing in the drainage from wet acid rocks and soil will probably uncover additional species and clarify the status of this genus.

Description of Species

Pleurodiscus borinquinae Tiffany 1936. *Brittonia.* 2, p. 169, Figs. 31–39.

Vegetative cells 18–26μ x 16–65μ, pectic sheath sometimes thick; filaments either simple or branched and having rhizoids; zygospores ovoid to ellipsoid, within a sporangium partly formed by the tube papillae and partly by a collar between them; zygospores 22–32μ x 26–32μ with a scrobiculate spore wall; pits 3 to 5μ in diameter. (Pl. XII, Figs. 12–15.)

Puerto Rico, Palmar, January to March (Wille Coll.).

CHAPTER SEVEN

THE GENUS MOUGEOTIOPSIS PALLA 1894

These algae have simple filaments, with vegetative cells one-half to four diameters long; each with a single quadrate, flat, or dished platelike axile chromatophore with a thickened and minutely granulate margin. The margin is sometimes inrolled, and *pyrenoids are absent.* Oil globules occur on the surface, and both starch granules and oil drops within the chromatophores. Reproduction is by short to long ovoid zygospores irregularly formed in the tube (isogamous) and extending into one or both gametangia, but not cut off from the gametangia by a wall. Only one species is known, from Europe and America.

This genus has had an interesting history beginning with the description and figures published by Palla (1894). In 1898 W. & G. S. West claimed to have found the same alga with pyrenoids and placed it in *Debarya.* In 1899 Brand described a new genus from southern Bavaria which he called *Mesogerron.* His description emphasized the dished or partly cup-shaped forms of the chromatophore and the absence of pyrenoids. His figure exaggerates the curled edges of the chromatophores, as shown by an examination of Brand's own specimens from Munich, which are in my possession. Brand thought that his plant belonged among the Ulotrichaceae, but Wille (1911) placed it provisionally among the Zygnemataceae. Skuja reported the occurrence of *Mesogerron* in Latvia in 1928, and in 1929 showed that "Mesogerron" is merely the vegetative form of *Mougeotiopsis.* Although Czurda (1932) insisted that the only important structure upon which genera of the Zygnemataceae may be based is the chromatophore, he includes this genus among the species of *Mougeotia* in spite of the absence of pyrenoids, the presence of oil droplets, and the unique thick-edged chromatophore entirely unlike that of any of the known species of *Mougeotia.* It might be added further that the zygospores, with their relatively thick and highly refractive median walls with deep sharp-edged pits, are equally unique

among the Zygnemataceae. Skuja's figures are the only ones that accurately represent either the vegetative or the reproductive structures.

Description of Species

Mougeotiopsis calospora Palla 1894. *Berichte deutsch. bot. Gesells.* 12, p. 228. Skuja. *Acta Horti Bot. Univ. Latviensis.* 1, p. 45, Pl. 2, Figs. 19–26. 1929.

Vegetative cells cylindric, 10–18μ x 10–70μ with plane end walls; 1 axial chromatophore with the nucleus beside it in the center of the cell; fertile cells similar or somewhat longer; conjugation scalariform; zygospores often irregularly placed and irregularly ovoid to quadrate-ovoid 16–23μ x 21–38μ; outer wall thin, transparent; median wall thick, deeply and sharply scrobiculate; pits 1.5–2.5μ in diameter, light yellow to brown in color. (Pl. XII, Figs. 16–17.)

United States: Wisconsin (Prescott Coll.); Michigan, Douglas Lake (Ackley Coll.).

Southern Bavaria; Austria; Czechoslovakia; Latvia.

In the American specimens I found conjugation occurring between filaments of all the various diameters so that it seems inadvisable to separate the smaller and larger forms as has been suggested by some authors.

CHAPTER EIGHT

THE GENUS DEBARYA WITTROCK 1872

Wittrock established the genus *Debarya* better to classify the *Mougeotia glyptosperma,* so lucidly described and figured by Anton de Bary in 1858. Since then several other species have been discovered with similar characteristics. The filaments are simple, made up of cells two to twenty diameters long with ribbonlike, or platelike, chromatophores with several distinct pyrenoids arranged either in a single row, or scattered. The nucleus is centrally located in the cell and attached to the side of the chromatophore. The *Debaryas* resemble the *Mougeotias* during the vegetative phase.

They differ from the *Mougeotias,* however, during the reproductive phase. At the beginning of conjugation, or during aplanospore formation, the reproductive cells become filled with a cellulose colloid deposited as successive layers inside the cell walls. Moreover, there are no cytoplasmic residues left in the gametangia outside the spore walls. Conjugation is scalariform, and the gametes unite in the conjugating tubes (isogamous). Aplanospores, parthenospores, and akinetes have been observed in 2 of the species.

The zygospores are compressed-spheroid, ovoid, or quadrangular-ovoid. The spores of 4 of the species are distinctly tricarinate, with an equatorial and two lateral keels. The median walls may be further ornamented with pits, radial ridges, and undulations.

All the 6 species are exceedingly rare, but they have been collected in Europe, Asia, North America, and New Zealand; they are probably more widely distributed than is surmised at the present time.

Several of the species that were formerly described as belonging to this genus have now been placed in the genera: *Mougeotia, Mougeotiopsis, Zygnemopsis,* and *Hallasia.*

Key to the Species of DEBARYA

1. Zygospore median wall tricarinate	2
1. Zygospore median wall quadrangular-ovoid	5. *D. hardyi*
1. Zygospore median wall globose to polyhedric	6. *D. polyedrica*
2. Polar surfaces with a distinct "hub"	1. *D. glyptosperma*
2. Polar surfaces without "hub"	3
3. Diameter vegetative cells 18 μ or more	4. *D. smithii*
3. Diameter vegetative cells less than 18 μ	4
4. Polar surfaces obscurely radially striate	2. *D. costata*
4. Polar surfaces obscurely pitted	3. *D. ackleyana*

Descriptions of Species

1. Debarya glyptosperma (de Bary) Wittrock 1872. *Bih. Kgl. Svensk Vetensk. Akad. Handl.* **1**, p. 35.

Vegetative cells 10–15 μ x 40–200 μ, with a single, axile, flat, ribbonlike chromatophore with 8 to 12 pyrenoids; conjugation scalariform, tubes very long (up to 80 μ), at first slender and increasing in width until spore is mature; spores formed in the tubes, compressed-ellipsoid or broadly ellipsoid, 30–46 μ x 42–72 μ; median spore wall tricarinate, yellow, with an irregular polar ring of protuberances; radially and distinctly corrugate between the "keels and hubs" when mature. (Pl. XII, Figs. 18–19.)

United States: Reported from New Hampshire, Minnesota, Florida.

Europe, widely distributed from Wales to Russia and Spain.

The variety "formosa" Transeau (1915) is an error.

2. Debarya costata Randhawa 1938. *Proc. Indian Acad. Sci.* **8**, p. 121, Fig. 2.

Vegetative cells 7–11 μ x 100–150 μ with a single axile ribbonlike chromatophore with 4 to 10 pyrenoids; conjugation scalariform with slender long tubes; zygospores, 36–44 μ x 38–50 μ, compressed-globose to ovoid, tricarinate with clearly defined ridges between the keels; the polar faces of the spores have no "hubs" as in *D. glyptosperma* but are obscurely and radially corrugate toward the margin. The color is bright yellow, and lateral keels are crinkly. (Pl. XII, Figs. 22–23.)

India, Fyzabad, U.P., December, 1936.

The specimens sent me by Randhawa contain mature spores, and the above description is based in part on this material.

3. DEBARYA ACKLEYANA Transeau 1944. *Ohio Jour. Sci.* **44**, p. 244.

Vegetative cells 12–15μ x 90–140μ, with a single ribbonlike axile chromatophore with about 8 pyrenoids; conjugation scalariform, tubes long and slender at first, later the median spore wall becomes rounded and the sporangium wall is perfectly distinct; zygospores golden yellow mostly compressed-globose, sometimes ovoid, 50–54μ x 52–65μ; median wall tricarinate, the lateral keels finely ruffled and very distinct, with corresponding corrugations between the keels; the middle keel is thin, radially striate and up to 10μ wide; polar walls obscurely pitted and without "hub." (Pl. XII, Figs. 20–21.)

United States: Michigan (Ackley Coll.); Massachusetts (Bullard Coll.).

Named for Dr. Alma Ackley who collected the type specimens near Douglas Lake, Michigan.

4. DEBARYA SMITHII Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 216.

Vegetative cells 21–28μ x 68–140μ, with 1 axile ribbonlike chromatophore containing 2 to 4 pyrenoids; reproduction by zygospores, conjugation scalariform; at time of conjugation, the chromatophores lengthen as they pass into the sporangium and each may then contain from 10 to 20 pyrenoids; zygospores compressed-globose or ovoid, 55–72μ x 64–80μ; the median wall strongly tricarinate with projecting ruffled ridges; the lateral wall between the keels is striate; the polar faces are distinctly and irregularly pitted, sometimes also finely punctate. This is the most elaborately ornamented species in the genus. (Pl. XII, Figs. 27–28.)

United States: California, Fresno (G. M. Smith Coll.).

Named for Gilbert M. Smith, Stanford University, author of *Freshwater Algae of the United States, Marine Algae of the Monterey Peninsula,* and many other contributions to phycology.

5. DEBARYA HARDYI G. S. West 1909. *Jour. Linn. Soc. of London Bot.* **39**, p. 51, Pl. 2.

Vegetative cells 6.5–8μ x 57–120μ with 1 ribbonlike chromatophore containing from 2 to 4 pyrenoids; judging by West's figures the number of pyrenoids increases during conjugation; conjugation scalariform; zygospores compressed-quadrangular, 22.5–27μ on a side. As the spores were immature, further details are unknown. It is possible that this alga may, when fully known, be placed in *Zygnemopsis.* (Pl. XII, Figs. 29–30.)

Australia, Victoria, Yan Yean Reservoir.

6. DEBARYA POLYEDRICA Skuja 1937. "Algae." *Symbolae Sinicae.* Pt. 1, p. 84, Pl. 2, Figs. 3–8.

Vegetative cells 8–12μ x 50–200μ, with 2 platelike chromatophores each containing 1 or 2 pyrenoids; reproduction by zygospores and aplanospores; conjugation scalariform; gametangia genuflexed and separating after conjugation; zygospores globose to polyhedric-ovoid, 26–33μ in diameter, completely filling the tubes; outer spore wall thick lamellate; median spore wall golden yellow, smooth; inner spore wall moderately thick, hyaline, irregularly scrobiculate within; aplanospores obliquely rotund-fusiform, 24μ x 42–54μ. (Pl. XII, Figs. 24–26.)

China, northwestern Yünnan on sinter terraces at an altitude of 2,765 meters, October 4, 1914.

CHAPTER NINE

THE GENUS MOUGEOTIA C. A. AGARDH 1824

Plants belonging to this genus were figured and described as early as 1803 by Vaucher in his *Histoire des Conferves*. Agardh, however, was the first to classify these plants in a way that clearly distinguished them from other "conjugates." During succeeding years of the nineteenth century there was much confusion about the nature of the group of cells now called the spore, sporangium, and the gametangia. Some authors interpreted the group of cells as the spore; others thought the gametangia and conjugating tube constituted a "carpogonium." When the gametangia became divided by the sporangium walls, the ends of the gametangia were looked upon as "sterile cells," since they are not empty but contain "cytoplasmic residues." Hence, many descriptions until those of very recent years contain the statement that the spore, or "fertile cell," is adjoined by two, three, or four "cells" instead of two, three, or four dead ends of the gametangia. Apparently, because of the "residues," many authors could not see the complete homology between these reproductive structures and those of *Zygnema*.

Because of the emphasis placed on the reproductive structures, the position of the "fertile cell" relative to the remnants of the gametangia became the basis of several genera which have been discarded by most authors. These generic names are only of historic interest and are listed at the end of the section. Plants of this genus are generally simple filaments of cylindric cells. Rarely one celled or two celled branches occur, particularly near the bases of filaments where the latter are anchored by coiling around a support or are attached to some substrate by rhizoids.

The vegetative cells are comparatively long, five to twenty diameters, with plane end walls that are thinnest at the center. Hence when the cells of a filament separate, the free ends are usually somewhat conical. Each cell has one or two axial, flat chromatophores extending the full length of young cells but

occupying only a part of the axis of mature cells. The nucleus is near the center of the cell, placed on one side of the chromatophore in those species which have a single chromatophore. In species with two chromatophores, such as *M. prona,* the nucleus lies in the bridge between the chromatophores. Under natural conditions favoring active growth the chromatophores of *M. capucina* may be either ribbonlike or rodlike, and the cells may have purple cell sap in some filaments instead of the usual colorless solution. The pyrenoids in most species are arranged in a linear row; in a few they are scattered throughout the broad platelike chromatophores.

Of the 99 species here described, 92 usually reproduce by means of zygospores, and 7 by aplanospores. Of the 92 zygosporic species, 25 also occasionally produce aplanospores either in the same filament with zygospores, or in separate aplanosporic filaments.

Scalariform conjugation occurs in 86 species. Conjugation may be either scalariform or lateral in 4 species, and in only 2 is it regularly lateral.

Almost all the species are isogamous; only 3 species are strictly anisogamous, and 2 others somewhat variable even in the same paired filaments. The distinction between parthenospores and aplanospores is not always easy to make. In many of the 25 species reproducing both by zygospores and aplanospores, the form and placement of the spores are somewhat different. In those species having aplanosporic filaments the distinction is more evident. These filaments are quite regularly zigzag with the spores at the angles, the first facing in one direction and the next in another direction. Hassall described such filaments in 1842, and figured an immature one in 1845 *(M. notabilis).* Wittrock (1878) also discussed this feature of aplanosporic filaments when he proposed the genus *Gonatonema.* Paul Petit (1880), the Wests (1902), and Czurda (1931) have suggested that these spores may result from internal division of a vegetative cell followed by lateral conjugation. This speculation still awaits cytological evidence. In the hundreds of developing aplanospores studied by me and my associates, not a single example of preliminary division of either the protoplast or the nucleus has been found. There is good reason to believe that rare instances of lateral conjugation may be found among the usually scalariform species of *Mougeotia* just as in *Zygnema* and *Spirogyra.* Such instances, however, can-

not be cited as proof that the aplanospores so commonly found among the *Mougeotias* are the result of lateral conjugation.

Two unusual growth processes occur among several species of *Mougeotia,* of which *M. genuflexa* and *M. reinschii* are the commonest examples; these are adhesion and genuflexion. It is true that as new filaments appear in some permanent ponds, new adhesions and genuflexions may continue to develop for several successive months. Apparently cells coming in contact produce growth substances which cause pectinization of the walls in contact and increased growth of the wall at the point of contact. The first results in adhesion; the second in genuflexion.

Genuflexion is not an early stage in conjugation that has been terminated before the development of tubes. There is no evidence that it has either an advantage or a purpose, although various authors have sought to find one. In one pond in which the process occurred throughout the growing season during several successive years, the interlocked filaments survived for a short time and then fragmented and went to the bottom. No zygospores were ever collected from this pond during the six years of observation.

The steps in conjugation in the *Mougeotias* as in the other genera in this family are probably activated in the same manner as those observed by J. R. Raper in *Achlya* (*Amer. Jour. Bot.* [1939–40]), a fungus in which the succession of hormones seems to have been established clearly.

Analogous changes occur in sexual reproduction though the cells are not necessarily in contact. The first visible changes are the growth of two papillae from nearby cells, until they meet, adhere, and the walls in contact are dissolved. Possibly other hormones lead to the movement of the protoplasts of both gametangia into the conjugating tube, which meanwhile has greatly enlarged, and growth has resulted in a form characteristic of the species. Then follows the union of gametes and the deposition of successive layers of the spore wall.

With a few exceptions zygospores and aplanospores of *Mougeotia* have only two walls—an outer chitinous wall variously colored and ornamented, and an inner transparent wall. In many species the spores are enclosed by a sporangium wall, in others the sporangium is merely a combination of gametangial and tube walls. In some species the outer layer of the sporangium wall changes to pectic compounds and forms a transparent layer 2 to

25μ in thickness. In a few species with quadrangular spores, pectose layers are formed between the sporangium wall and the spore. Most species have yellow to brown spores; 8 species have blue spores.

Only during the reproductive phases of the life cycle can species of *Debarya* and *Temnogametum* be separated with certainty from those of *Mougeotia.*

Many of the published figures of *Mougeotias* do not show cytoplasmic residues in the gametangia after union of the gametes, because they are of little or no significance in the identification of species. However, they are present in all species of the genus now known.

The generic names formerly applied to certain species of *Mougeotia* include the following: *Sphaerocarpus* Hassall 1843; *Mesocarpus* Hassall 1845; *Pleurocarpus* Braun 1855; *Staurospermum* Braun 1855; *Craterospermum* Braun 1855; *Plagiospermum* Cleve 1868; *Sphaerospermum* Cleve 1868; *Gonatonema* Wittrock 1878. Czurda 1932 included among the *Mougeotias* certain species here classified in the genera: *Debarya, Mougeotiopsis,* and *Temnogametum.*

Key to the Species of MOUGEOTIA

1. With zygospores (rarely aplanospores also present) 2
1. With aplanospores (zygospores rare or unknown) 69
   2. Sporangium between 2 undivided gametangia 3
   2. Sporangium dividing 1 of the gametangia 45
   2. Sporangium dividing both gametangia 48
3. Sporangia globose, subglobose, ovoid, ellipsoid or dolioform, longer axis parallel with the conjugating tube 4
3. Sporangia cylindric-oblong with concave sides and rounded ends 35
3. Sporangia with longer axes at right angles to the conjugating tubes 38
   4. Spore wall smooth 5
   4. Spore wall not smooth 22
5. Diameter vegetative cells usually less than 24μ 6
5. Diameter vegetative cells usually more than 24μ 17
   6. Vegetative cells usually less than 12μ in diameter 7
   6. Vegetative cells usually between 12μ and 24μ in diameter 11
7. Spores globose 8
7. Spores ellipsoid or ovoid, longer axis same as that of tube 10

7. Spores globose to ovoid, variable in position, some extending into and dividing one or both of the gametangia . . . 5. *M. calcarea*

8. Spores colorless with thick outer pectic layer . . . 7. *M. victoriensis*
8. Spores brown . . . 9
8. Spores blue . . . 11. *M. kerguelensis*

9. Diameter spores 7–8 μ, outer wall brown . . . 1. *M. angusta*
9. Diameter spores 13–24 μ, outer wall brown . . . 3. *M. parvula*

10. Spores ovoid, longer axis 11–15 μ . . . 2. *M. tenuissima*
10. Spores asymmetric, ellipsoid or dolioform, longer axis 30–42 μ, outer sporangium wall a thick pectic layer . . . 4. *M. tubifera*
10. Spores ellipsoid, longer axis 20–28 μ . . . 6. *M. ellipsoidea*

11. Spores variable in position in the conjugating tube or dividing one or both gametangia . . . 5. *M. calcarea*
11. Spores globose or subglobose . . . 12
11. Spores ovoid to quadrate-ovoid . . . 16

12. Spores blue, vegetative cells about 12 μ in diameter . . . 11. *M. kerguelensis*
12. Spores blue, vegetative cells about 17–22 μ in diameter . . . 12. *M. maltae*
12. Spores brown or yellow . . . 13

13. Filaments mostly less than 20 μ in diameter . . . 14
13. Filaments mostly more than 20 μ in diameter . . . 15

14. Spores globose, contained in the conjugating tubes . . . 8. *M. recurva*
14. Spores globose, extending into the gametangia . . . 10. *M. drouetii*
14. Spores globose, ovoid or ellipsoid . . . 9. *M. adnata*
14. Spores rhomboid, usually lateral conjugation . . . 13. *M. reinschii*

15. Diameter of spores about 30–40 μ . . . 15. *M. scalaris*
15. Diameter of spores about 40–45 μ . . . 14. *M. sphaerocarpa*
15. Diameter of spores 47–52 μ . . . 16. *M. jogensis*

16. Spore diameter about 24–30 μ, conjugation mostly lateral . . . 13. *M. reinschii*
16. Spores 36–40 μ x 40–55 μ, diameter vegetative cells 19–24 μ . . . 14. *M. sphaerocarpa*

17. Diameter vegetative cells 24–40μ.......................... 18
17. Diameter vegetative cells more than 40μ.................... 21
   18. Spores 30–48μ in diameter.............................. 19
   18. Spores 47–52μ in diameter........ 16. *M. jogensis*
   18. Spores 55–70μ in diameter........ 21. *M. macrospora*
19. Spores about 30–40μ in diameter 20
19. Spores ovoid about 40μ x 50–59μ..... 18. *M. ovalispora*
19. Spores about 40–50μ in diameter...... 19. *M. hirnii*
19. Spores about 45–55μ in diameter...... 17. *M. africana*
   20. Conjugation usually lateral....... 20. *M. genuflexa*
   20. Conjugation usually scalariform .. 15. *M. scalaris*
21. Spores about 50μ in diameter........ 22. *M. subcrassa*
21. Spores about 65μ in diameter........ 23. *M. crassa*
   22. Diameter vegetative cells less than 16μ.................. 23
   22. Diameter vegetative cells more than 16μ.................. 24
23. Spores ovoid, 18–20μ x 21–25μ, light yellow, punctate .... 24. *M. caelestis*
23. Spores compressed-ovoid, rarely subglobose (about 30–36μ).............. 50. *M. ovalis*
23. Spores globose to ovoid, brown (about 22–32μ) .... 25. *M. nummuloides*
   24. Chromatophores with pyrenoids in a single row......... 25
   24. Chromatophores with pyrenoids scattered............... 30
25. Spores globose or subglobose.................................. 26
25. Spores ovoid to ellipsoid..................................... 29
   26. Diameter of spores usually less than 32μ (in No. 28, 28–35μ) 27
   26. Diameter of spores 32μ or more (in No. 28, 28–35μ)..... 28
27. Spore wall reticulate................. 26. *M. sinensis*
27. Spore wall coarsely punctate.......... 29. *M. micropora*
27. Spore wall punctate.................. 28. *M. ornata*
   28. Diameter spores 32–38μ.......... 36. *M. globulispora*
   28. Diameter spores 40–50μ.......... 27. *M. megaspora*
29. Spore length 28–45μ, wall verrucose, outer wall thick..................... 34. *M. lamellosa*
29. Spore length 40–50μ, wall verrucose, outer wall thin...................... 35. *M. microverrucosa*
29. Spore length 40–50μ, wall punctate... 37. *M. pulchella*
29. Spore length 35–50μ, wall scrobiculate 38. *M. laevis*
29. Spore length 50–70μ, wall areolate.... 30. *M. areolata*
   30. Spores globose to subglobose.......................... 31

30. Spores ovoid 40–54μ in length 34
31. Diameter vegetative cells 17–24μ 32
31. Diameter vegetative cells 32–38μ 33
32. Diameter spores about 30μ, wall wrinkled .... 33. *M. gotlandica*
32. Diameter spores 42–50μ, median wall scrobiculate .... 32. *M. talyschensis*
33. Spore diameter about 39–46μ, rather densely punctate .... 40. *M. daytonae*
33. Spore diameter 40–42μ, sparsely scrobiculate .... 41. *M. handelii*
33. Spore diameter about 60–68μ .... 42. *M. sanfordiana*
34. Spores extending into the gametangia .... 31. *M. sumatrana*
34. Spores wholly in the conjugating tube .... 39. *M. robusta*
35. Vegetative cells less than 30μ in diameter, pyrenoids in single row 36
35. Vegetative cells more than 30μ in diameter, pyrenoids scattered 37
36. Diameter vegetative cells 14–22μ, spores 28–36μ x 47–58μ .... 43. *M. oblongata*
36. Diameter vegetative cells 25–29μ, spores 19–21μ x 19–21μ .... 45. *M. angolensis*
36. Diameter vegetative cells 25–28μ, spores 55–64μ x 30–34μ .... 48. *M. opelousensis*
37. Diameter vegetative cells 35–40μ ...... 46. *M. laetevirens*
37. Diameter vegetative cells 43–53μ ...... 47. *M. acadiana*
38. Outer sporangium wall a thick pectic layer 39
38. Sporangia without pectic layer (possibly present when young) 43
39. Spores blue, wall with scattered scrobiculations .... 98. *M. cotopaxiensis*
39. Spores blue, finely punctate .... 55. *M. cyanea*
39. Spores blue, coarsely punctate .... 56. *M. atubulosa*
39. Spores colorless, smooth .... 51. *M. pectosa*
39. Spores yellow, brown, or chestnut brown 40
39. Spores metallic green .... 97. *M. chlamydata*
40. Spores yellow to brown 41
40. Spores dark chestnut brown 42
41. Spore wall smooth .... 52. *M. gelatinosa*
41. Spore wall punctate .... 29. *M. micropora*

41. Spore wall scrobiculate................ 58. *M. pawhuskae*
41. Spore wall irregularly corrugate...... 54. *M. oedogonioides*
    42. Diameter vegetative cells 14–18 μ.. 53. *M. disjuncta*
    42. Diameter vegetative cells 20–25 μ.. 59. *M. seminoleana*

43. Diameter vegetative cells less than 16 μ........................ 44
43. Diameter vegetative cells 18–21 μ, spores blue, punctate .... 55. *M. cyanea*
43. Diameter vegetative cells 18–21 μ, spore wall shallow-scrobiculate, brown...... 57. *M. operculata*
    44. Spores 28–32 μ x 12–14 μ, walls punctate .... 49. *M. depressa*
    44. Spores 29–38 μ x 26–36 μ, walls coarsely punctate .... 50. *M. ovalis*
    44. Spores 32–34 μ in diameter, walls blue, scrobiculate .... 98. *M. cotopaxiensis*

45. Spores globose, or 3 lobed filling the sporangium............ 46
45. Spores variable in position, 30–50 μ in length .... 5. *M. calcarea*
45. Spores variable in position, cylindric, 60–78 μ .... 44. *M. varians*
    46. Diameter vegetative cells less than 14 μ .... 60. *M. transeaui*
    46. Diameter vegetative cells more than 14 μ................. 47

47. Vegetative cells between 14 and 20 μ in diameter .... 61. *M. floridana*
47. Vegetative cells between 21 and 25 μ in diameter .... 62. *M. poinciana*
    48. All spore walls smooth (inwardly granulose in No. 69).. 49
    48. Spore walls not smooth................................ 61

49. Diameter vegetative cells less than 14 μ...................... 50
49. Diameter vegetative cells more than 14 μ.................... 59
    50. Spores compressed-globose, diameter vegetative cells 12–13 μ........ 99. *M. kwangsiensis*
    50. Spores globose, diameter vegetative cells 7–9 μ .... 64. *M. cherokeana*
    50. Spores globose, diameter vegetative cells 4–5 μ .... 63. *M. caimani*
    50. Spores quadrate-ovoid, with or without processes......... 51

51. Angles of zygospores rounded, undulate, or truncate......... 52
51. Angles of zygospores retuse, margins concave................ 55
51. Angles produced, extending into gametangia................. 56

52. Zygosporangia regularly dividing the gametangia........ 53
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Aplanospores have been observed in scattered cells, or entire filaments of the following species that regularly reproduce by zygospores: *M. africana, M. americana, M. areolata, M. caelestis, M. calcarea, M. capucina, M. cyanea, M. elegantula, M. floridana, M. gracillima, M. laetevirens, M. nummuloides, M. parvula, M. pectosa, M. poinciana, M. producta, M. quadrangulata, M. recurva, M. seminoleana, M. sphaerocarpa, M. thylespora, M. transeaui, M. tumidula, M. uberosperma, M. viridis.*

Descriptions of Species

1. Mougeotia angusta (Hassall) Kirchner 1878. *Kryptogamenflora Schlesien,* p. 128.

Vegetative cells 5–6μ x 30–95μ; chromatophores with 4 pyrenoids in a row; conjugation scalariform; zygospores formed wholly in the conjugating tube, globose, about 7–8μ in diameter; spore wall brown, smooth. (Pl. XIII, Fig. 1.)

United States: South Carolina.

British Isles; Germany; Austria; Belgium; Bulgaria; Czechoslovakia; North Africa; Netherland Indies.

2. Mougeotia tenuissima (de Bary) Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 66.

Vegetative cells 5–6μ in diameter; conjugation scalariform; zygospores formed wholly in the conjugating tube, ovoid, 11–15μ x 12–14μ; spore wall brown, thick, smooth. (Pl. XIII, Fig. 2.)

Germany; France.

3. Mougeotia parvula Hassall 1843. *Ann. and Mag. Nat. Hist.* **11**, p. 434.

Vegetative cells 8–13μ x 30–140μ; chromatophore usually occupying two-thirds of the cell, with 4–8 pyrenoids; conjugation scalariform; zygospores formed wholly in the conjugating tube, globose, 13–25μ in diameter; spore wall brown, thick, smooth; aplanospores obliquely ovoid, 16–20μ x 20–24μ. (Pl. XIII, Figs. 3–5.)

United States: Iowa to Massachusetts; south to Louisiana and Florida.

Widely distributed in Europe; China; Japan; Brazil; Africa.

4. Mougeotia tubifera Tiffany 1934. *Trans. Amer. Micros. Soc.* **53**, p. 218.

Vegetative cells 9–10μ x 90–400μ; chromatophore with 4–12 pyrenoids in a single, more or less irregular, row; conjugation tubes usually greatly elongated (10–65μ), often spirally twisted and nearly as large as the filaments (7–9μ in diameter). Conjugation occurs through the lateral wall of the papillae as well as through the end. Zygospores asymmetrically ovoid, usually showing a greater bulge on one side than on the other, 27–30μ x 33–45μ, not including the outer sporangial pectic layer which is 6–12μ in thickness; sporangium wall smooth, hyaline; spore wall colorless, thicker, smooth. It is not certain that the spores were fully mature. (Pl. XIII, Figs. 6–9.)

United States: Florida; North Carolina.

5. Mougeotia calcarea (Cleve) Wittrock 1872. *Bih. Kgl. Svensk Vetensk. Akad. Handl.* **1**, p. 40, Pl. 2.

Vegetative cells 8–14μ x 40–280μ; chromatophores with 4–8 pyrenoids in a single row; cells elongating, becoming geniculate before spore formation; conjugation scalariform; zygospores formed wholly in the conjugating tube or extending into one or both gametangia, globose, 25–30μ in diameter, or angular-globose, 22–28μ x 30–50μ; spore wall smooth, colorless, or pale yellow; aplanospore globose, lateral to the sporogenous cell, 17–21μ in diameter, or rarely trapezoid-ovoid, dividing the sporogenous cell, 15–20μ x 20–28μ. (Pl. XIII, Figs. 10–12.)

North America, British Columbia to Greenland; Dakota to Texas and eastward to Newfoundland and Florida.

Brazil; Europe; North Africa; southern Asia.

The variety name "bicalyptrata" has been applied to specimens in which the thickness of the end walls of the sporangium is unusually great. In some collections the thick polar walls occur in filaments among spores with thin uniform walls. Collections may contain only aplanosporic or only zygosporic specimens, while others may contain both in mixture. In Borge's type material for *M. sphaerospora* I found 2 zygospores similar to those of *M. calcarea;* moreover, I found no aplanospores resembling those figured by Czurda from Central Tibet as *M. sphaerospora.* This figure may represent a new species but descriptive details are lacking.

6. Mougeotia ellipsoidea (W. & G. S. West) Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 66.

Vegetative cells 9.5–11.5μ in diameter; conjugation scalariform; zygospores formed wholly in the conjugating tube, ellipsoid, 16–26μ x 22–28μ; spore wall smooth, brown at maturity. (Pl. XIII, Fig. 14.)

Burma; Austria.

7. Mougeotia victoriensis G. S. West 1909. *Jour. Linn. Soc. of London Bot.* **39**, p. 51.

Vegetative cells 11–12μ x 100–160μ; chromatophores with 2–7 (usually 5–6), pyrenoids in a single, more or less irregular row; conjugation scalariform; zygospores formed wholly in the conjugating tube, globose, 21–24μ in diameter; spore wall smooth. Surrounding the sporangium a layer of pectic material develops which extends even beyond the outer sides of the gametangia, 60–63μ in diameter. (Pl. XIII, Fig. 18.)

Australia, Victoria.

8. Mougeotia recurva (Hassall) de Toni 1889. *Sylloge Algarum.* **1**, p. 714.

Vegetative cells 12–18μ x 50–180μ; chromatophores with 4–8 pyrenoids; conjugation scalariform; zygospores formed wholly in the conjugating tube, globose, 22–33μ in diameter; spore wall brown, smooth; aplanospores globose, 24–30μ in diameter, at the bends in geniculate cells, or cylindric-ovoid, 14–18μ x 28–34μ, in straight cells. (Pl. XIII, Fig. 13.)

United States: Michigan; Florida.

Maritime Provinces of Canada; British Isles; Germany; Australia; Puerto Rico; South America; northern India.

In the collection from Florida the spores, although mature, were highly variable in dimensions.

9. Mougeotia adnata Iyengar 1932. *Rev. Algolog.* **6**, p. 270, Fig. 3.

Vegetative cells 15–17μ x 180–240μ, enveloped by a sheath 6–8μ thick; chromatophore platelike, with 4–10 pyrenoids in a row; conjugation lateral and scalariform; zygospores formed in the enlarged conjugating tube, which also develops an outer pectic layer; in lateral conjugation ellipsoid or rarely reniform, 26–32μ x 30–38μ; in scalariform conjugation globose or dolioform, 31–33μ x 35–37μ; spore wall brown, smooth. (Pl. XIII, Figs. 15–17.)

India, Periyar, on wet rock slopes.

10. Mougeotia drouetii Transeau 1938. *Amer. Jour. Bot.* **25**, p. 524, Fig. 1.

Vegetative cells 14–18 μ x 72–180 μ, with 4 to 8 pyrenoids in a single row; conjugation scalariform; zygospores globose in the enormously enlarged tube and extending into the gametangia, 32–37 μ x 33–42 μ; spore wall smooth, yellow-brown, obscured by the granular membranous residue left after conjugation. (Pl. I, Fig. 10.)

South America, Brazil, state of Ceará, Fortaleza (Drouet Coll.).

11. Mougeotia kerguelensis Krieger 1941. *Rabenhorst's Kryptogamenflora.* 13 (2), p. 134.

Vegetative cells about 12 μ x 48–96 μ; chromatophore with several pyrenoids in a single row; conjugation scalariform; zygospores in the conjugating tubes, sometimes extending slightly into the gametangia, about 27 μ in diameter; spore wall smooth, dark blue. (Pl. XIV, Fig. 1.)

Kerguelen Islands, South Indian Ocean (Werth Coll.).

12. Mougeotia maltae Skuja 1926. *Acta Horti Bot. Univ. Latviensis.* **1**, p. 109, Fig. 1.

Vegetative cells 17–22 μ x 60–120(–200) μ; chromatophore nearly as long as the cell, with 4–8 pyrenoids in a single row; conjugation scalariform; zygospores formed wholly in the conjugating tube, globose (30–)32–35(–40) μ in diameter; spore wall blue, smooth, surrounded by a gelatinous layer 4–6 μ in diameter. (Pl. XIV, Fig. 2.)

Latvia, Usma Lake.

13. Mougeotia reinschii Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 224.

Vegetative cells 15–24 μ in diameter; chromatophore with 4–8 pyrenoids in a single row; conjugation lateral, very rarely scalariform; zygospores quadrately ovoid, 24–30 μ x 26–32 μ; spore wall brown, smooth. (Pl. XIV, Fig. 3.)

United States: Illinois; Ohio.

Germany; Poland; Czechoslovakia; Java.

In a collection from Fayetteville, Ohio, May 8, 1934, several spores resulting from scalariform conjugation were found among the hundreds resulting from lateral conjugation. Formerly classified as *Mougeotia gracilis* (Reinsch) Czurda.

14. Mougeotia sphaerocarpa Wolle 1887. *Freshwater Algae of the United States,* p. 227, Pl. 146, Figs. 1–2.

Vegetative cells 19–24 μ x 60–120(–240) μ; chromatophore platelike, with 4–16 pyrenoids in an irregular row; conjugation scalariform; zygospores formed in the greatly enlarged conjugating tubes and ex-

tending somewhat into both gametangia, ovoid to subglobose, 36–40 μ x 40–55 μ; spore wall brown, smooth; aplanospores ovoid to obliquely ovoid, 24–30 μ x 35–50 μ. (Pl. XIV, Figs. 4–6.)

United States: Generally distributed throughout.

China, several provinces (Li and Jao); India.

In some collections aplanosporic filaments are more abundant than conjugating filaments.

15. Mougeotia scalaris Hassall 1842. *Ann. and Mag. Nat. Hist.* **10**, p. 45.

Vegetative cells 20–34 μ x 40–180 μ; chromatophores with 4–10 pyrenoids in a single row; fertile cells straight or slightly curved; conjugation scalariform; zygospores formed wholly in the conjugating tube, ovoid to globose, 30–38(–40) μ in diameter; spore wall yellow-brown, smooth. (Pl. XIV, Figs. 7–8.)

United States: Generally distributed in the eastern half.

Southern Ontario; widely reported from Europe; China; Japan; India; New Caledonia; Queensland.

16. Mougeotia jogensis Iyengar 1932. *Rev. Algolog.* **6**, p. 268, Fig. 2.

Vegetative cells 22–26 μ x 100–200 μ, with a pectic sheath 6–7 μ in thickness; chromatophores platelike with 4–8 pyrenoids in a single row; conjugation scalariform and lateral; zygospores formed in the greatly enlarged conjugating tubes and finally cut off from the adjoining gametangia by lamellate thickenings of the sporangium wall; zygospores globose to ellipsoid, 47–52 μ in diameter; spore wall brown, smooth. (Pl. XIV, Figs. 9–10.)

India, Mysore.

The tube primordia in lateral conjugation sometimes arise at some distance from the partition walls.

17. Mougeotia africana (G. S. West) Transeau 1944. *Ohio Jour. Sci.* **44**, p. 244.

Vegetative cells 24–28 μ x 44–200 μ; chromatophore with 4–16 pyrenoids in a single row; conjugation scalariform; zygospores in the greatly enlarged conjugating tubes and extending nearly or quite across the gametangia, globose to ovoid, 35–44 μ x 44–60 μ; spore wall brown, smooth; walls of gametangia usually thickened by an apparent change to pectic compound, and superficially suggesting a *Debarya,* readily distinguished from the latter, however, by the absence of completely filled gametangia; aplanospores and parthenospores ovoid, 20–25 μ x 22–30 μ, formed near the middle of the sporogenous cells. (Pl. XIV, Figs. 11–12.)

Philippine Islands; Africa.

This species has been previously classified as *Debarya africana* G. S. West, and as *M. sphaerocarpa* var. *varians* Transeau.

18. MOUGEOTIA OVALISPORA Krieger 1941. *Rabenhorst's Kryptogamenflora.* 13 (2), p. 134.

Vegetative cells 37–40μ x 80–120μ; chromatophores with 8 to 10 scattered pyrenoids; conjugation scalariform; zygospores in the conjugating tubes, ovoid to ellipsoid, 39–41μ x 51–59μ; spore wall thick, smooth, yellow-brown. (Pl. XIV, Fig. 14.)

Germany, Brandenburg, Grünrade.

19. MOUGEOTIA HIRNII Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 218.

Vegetative cells 25–28μ x 60–140μ; chromatophores with 4–8 pyrenoids in a row; conjugation scalariform; zygospores formed wholly in the conjugating tube, ovoid, 40–48μ x 43–50μ; spore wall yellow-brown, smooth. (Pl. XIV, Fig. 13.)

United States: Michigan (Ackley Coll.).

Finland; China (McClure Coll.).

Formerly classified as *M. scalaris* var. *macrospora* Hirn.

20. MOUGEOTIA GENUFLEXA (Dillwyn) C. A. Agardh 1824. *Systema Algarum,* p. 83.

Vegetative cells 25–38μ x 50–225μ, often geniculate and attached to other similar cells, forming extensive nets, sometimes with rhizoidal branches; conjugation lateral, less frequently scalariform; zygospores quadrately ovoid to globose, 30–40μ in diameter; spore wall smooth, brown. (Pl. XIV, Figs. 16–17.)

United States: Minnesota and Wisconsin to Louisiana; eastward to Massachusetts and Florida.

Generally distributed in Europe; China, Kiangsi; Manchuria; Morocco.

21. MOUGEOTIA MACROSPORA (Wolle) de Toni 1889. *Sylloge Algarum.* **1**, p. 716.

Vegetative cells about 30μ x 180–300μ; conjugation scalariform; zygospores formed in the conjugating tubes, globose, 55–70μ in diameter; spore wall smooth. (Pl. XIV, Fig. 15.)

United States: Pennsylvania; New Hampshire.

22. MOUGEOTIA SUBCRASSA G. S. West 1909. *Jour. Linn. Soc. of London Bot.* **39**, p. 50.

Vegetative cells 41.5–43μ x 240–280μ; chromatophore with 15–24 pyrenoids arranged irregularly; gametangia straight or slightly curved;

conjugation scalariform; zygospores formed in the conjugating tube, globose, 40–41 μ in diameter; spore wall smooth and indistinctly lamellate; sporangial wall thicker at the ends of the tube. (Pl. XIV, Fig. 18.)

Australia, Victoria.

23. Mougeotia crassa (Wolle) de Toni 1889. *Sylloge Algarum.* I, p. 716.

Vegetative cells about 50 μ x 200–500 μ; conjugation scalariform; zygospores in the greatly enlarged conjugating tube, globose, about 65 μ in diameter; spore wall smooth.

United States: Florida.

24. Mougeotia caelestis Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 218.

Vegetative cells about 7–9 μ x 50–75 μ; chromatophore with 2–6 pyrenoids, usually 4; conjugation scalariform; zygospores in the conjugating tube, rarely extending slightly into the gametangia, ovoid to subglobose, 18–20 μ x 21–25 μ; spore wall light yellow, punctate; reproduction usually by aplanospores; aplanospores globose to subglobose, usually near the middle of the cell, either dividing it or wholly external, rarely terminal, 16–18 μ in diameter; spore wall as in zygospores. (Pl. XV, Fig. 1.)

United States: Oklahoma; Florida.

Named for the collector Celeste Taft.

25. Mougeotia nummuloides (Hassall) de Toni 1889. *Sylloge Algarum.* I, Pt. 2, p. 713.

Vegetative cells 8–16 μ x 32–160 μ; chromatophores with 2–6 pyrenoids in a row; conjugation scalariform; zygospores in the conjugating tubes, globose to ovoid (17–)22–32(–37) μ in diameter; spore wall brown, scrobiculate; aplanospores ovoid, within the angled sporogenous cell. (Pl. XV, Figs. 2–3.)

United States: Iowa to Maine; North Carolina; Florida.

British Isles to Finland and Bulgaria.

Specimens collected from a fountain, Miami Beach, May 2, 1926, were fruiting abundantly and had many filaments with several-celled branches.

26. Mougeotia sinensis Li 1933. *Ohio Jour. Sci.* 33, p. 152.

Vegetative cells 15–22 μ x 100–132 μ; chromatophore with 4–6 pyrenoids in a single row; conjugating cells slightly geniculate; conjugation scalariform; zygospores in the conjugating tube, ovoid to globose, 25–31 μ x 25–31 μ; spore wall yellow-brown, angularly reticulate. (Pl. XV, Fig. 4.)

China, Tinghai.

27. Mougeotia megaspora Wittrock 1872. *Bih. Kgl. Svensk Vetensk. Akad. Handl.* **1** (1).

Vegetative cells 17–21 μ x 170–380 μ; conjugation scalariform; zygospores in the conjugating tube, globose, 40–50 μ, or ovoid, 41–44 μ x 45–48 μ; spore wall brown, irregularly scrobiculate. (Pl. XV, Fig. 5.)

United States: Florida, Daytona Cypress Swamp (Tiffany Coll.). Sweden.

28. Mougeotia ornata Jao 1935. *Sinensia.* **6**, p. 577, Figs. 34–35.

Vegetative cells 16–22 μ x 76–176 μ; chromatophores with 4–10, usually 6, pyrenoids in a single row; gametangia straight; conjugation scalariform; zygospores in the conjugating tubes, globose to subglobose, 28–35 μ in diameter; spore wall thick, more or less regularly and distinctly punctate, with a prominent, ridged suture; margin of ridge finely undulate; yellowish-brown at maturity. (Pl. XV, Figs. 6–7.)

China, Szechwan. Collection of C. C. Jao, Herbarium, University of Michigan, No. S587.

29. Mougeotia micropora Taft 1934. *Trans. Amer. Micros. Soc.* **53**, p. 218, Fig. 62.

Vegetative cells 18–23 μ x 60–160 μ; chromatophores with 4–6 pyrenoids in a row; conjugation scalariform; zygospores in the conjugating tube, globose to ovoid, or rarely slightly compressed-ovoid, 26–36 μ x 26–30 μ; outer sporangium wall a pectic layer 5–12 μ in thickness; spore wall brown, distinctly punctate; pores .5–1 μ in diameter. (Pl. XV, Fig. 8.)

United States: Oklahoma; Michigan; Florida.

30. Mougeotia areolata Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 219, Figs. 47–49.

Vegetative cells 17–26 μ x 90–400 μ; cross walls more refractive than lateral walls and slightly colligate; chromatophores with 4–10 pyrenoids in a row, occupying from two-thirds to one-fourth the cell length; conjugation scalariform; zygospores in the conjugating tubes, dolioform, with the ends short or extended, 43–50 μ x 50–70 μ; wall frequently in 3 layers, the outer a thin, yellow, minutely punctate membrane, the second a heavy, yellow areolate wall with a prominent equatorial ridge and suture, the innermost wall thin and hyaline; aplanospores asymmetrically ovoid, 27–33 μ x 55–66 μ, markings similar to those of the zygospores. (Pl. XV, Figs. 9–11.)

United States: Florida, Oveida Springs (O'Neil Coll.).

31. Mougeotia sumatrana Schmidle 1895. *Hedwigia.* **34**, p. 297.

Vegetative cells 20–24 μ x 80–220 μ; chromatophore with scattered

pyrenoids; gametangia somewhat shorter and thicker walled than the vegetative cells; conjugation scalariform; zygospores formed in the enlarged conjugating tube and extending into the gametangia, ovoid, about 42 μ x 52 μ; spore wall brown, "granulate." (Pl. XV, Fig. 12.)

Sumatra.

32. Mougeotia talyschensis (Woronichin) Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 73.

Vegetative cells 19–21 μ x 80–100 μ; conjugation scalariform; zygospores formed in the broad conjugating tube, globose, 42–50 μ in diameter; spore wall yellow-brown, punctate. (Pl. XV, Fig. 13.)

Russia, Baku; Manchuria.

33. Mougeotia gotlandica (Cleve) Wittrock 1872. *Bih. Kgl. Svensk Vetensk. Akad. Handl.* 1 (1).

Vegetative cells about 17–24 μ x 75–150 μ; chromatophore with scattered pyrenoids; conjugation scalariform; zygospores in the conjugating tubes, globose, about 30–34 μ in diameter; spore wall yellow-brown, wrinkled. (Pl. XV, Fig. 14.)

Sweden; Latvia; Estonia; Luxemburg; India (Randhawa Coll.); China (Li Coll.).

34. Mougeotia lamellosa Jao 1935. *Sinensia.* 6, p. 577.

Vegetative cells 19–30 μ x 60–185 μ; chromatophore with 4–9 pyrenoids in a row; conjugation scalariform; zygospores in the conjugating tube, ellipsoid, 24–32 μ x 28–45 μ; outer spore wall smooth, lamellose, thick, especially on the ends; spore wall yellow, verrucose. (Pl. XV, Figs. 18–19.)

China, Chungking, January, 1933; France, Falaise (Leo Lesquereux Coll.).

The collection from Falaise, France, must have been made about a hundred years ago, but the filaments and spores are in excellent condition. This material is a part of a collection purchased from Leo Lesquereux by the Philadelphia Academy of Sciences. Dr. Ruth Patrick identifies the handwriting on the label as that of Brébisson.

35. Mougeotia microverrucosa Krieger 1941. *Rabenhorst's Kryptogamenflora.* 13 (2), p. 155.

Vegetative cells about 27 μ x 70–108 μ; chromatophores with several pyrenoids in a single row; conjugation scalariform; zygospores filling the conjugating tubes, ovoid, 33–36 μ x 44–49 μ; spore wall irregularly verrucose; elevations about 1 μ in diameter. (Pl. XV, Fig. 20.)

Germany, Brandenburg, Trebnitz.

36. Mougeotia globulispora Jao 1935. *Sinensia.* **6**, p. 578.

Vegetative cells 19–32 μ x 96–228 μ; chromatophore with 10–12 pyrenoids in a single row; conjugation scalariform; zygospores in the conjugating tubes, globose to subglobose, 32–38.4 μ x 32–35 μ; spore wall yellow-brown at maturity, finely and closely scrobiculate. (Pl. XV, Figs. 15–16.)

China, Chungking, February, 1932, and January, 1933; Puerto Rico.

37. Mougeotia pulchella Wittrock 1871. *Hedwigia* (1871), p. 88.

Vegetative cells 24–29 μ x 48–150 μ; chromatophores with 4–8 pyrenoids in a row; conjugation scalariform; zygospores in the conjugating tubes, ovoid to ellipsoid, with ends more or less flattened, 28–35 μ x 40–50 μ; spore wall yellow-brown, punctate. (Pl. XVI, Fig. 1.)

United States: Minnesota; Michigan; Indiana.

Sweden; Latvia; Finland; Germany; China, Kiangsi.

38. Mougeotia laevis (Kützing) Archer 1866. *Quart. Jour. Micros. Soc.* **6**, p. 272, and **7**, Pl. 8, Figs. 1–3. Kützing. *Species Algarum,* p. 447. 1849.

Vegetative cells 20–36 μ x 20–100 μ; chromatophores with 2 to 4 pyrenoids in a row; conjugation scalariform; zygospores ellipsoid to ovoid, 20–36 μ x 35–50 μ; wall scrobiculate; pits about 3 μ in diameter, 2–3 μ apart. (Pl. XV, Fig. 17.)

United States: Wisconsin (G. M. Smith Coll.).

England and Finland to Poland; Yugoslavia; North Africa.

39. Mougeotia robusta (de Bary) Wittrock 1885. Wittrock and Nordstedt Algae Exsiccatae, No. 651.

Vegetative cells 25–33 μ x 75–260 μ; chromatophores with 10–20 scattered pyrenoids; conjugation scalariform; zygospores in conjugating tubes, ovoid to subglobose, 35–41 μ x 47–58 μ; spore wall brown, scrobiculate; pits 1–1.6 μ in diameter, scattered. (Pl. XVI, Figs. 2–4.)

United States: Iowa; Michigan; Illinois; eastward to Massachusetts and New Jersey.

France; Germany; Sweden; Finland; Latvia; Ceylon; Japan; North Africa.

Filaments with chromatophores having V-shaped ends or divided all the way to the nucleus are not uncommon in some collections. These chromatophores have sometimes been described as "double," or as 2 separate chromatophores.

40. Mougeotia daytonae Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 219, Fig. 55.

Vegetative cells 32–36 μ x 100–250 μ; chromatophores with numer-

ous scattered pyrenoids; conjugation scalariform; zygospores in the conjugating tube, globose, 40–45 μ in diameter, or subglobose, 39–42 μ x 45–50 μ; spore wall yellow, coarsely and irregularly punctate; pits about 1.5 μ in diameter and about the same distance apart. (In the specimens seen the wall is also irregularly contracted and reticulate-wrinkled.) (Pl. XVI, Fig. 5.)

United States: Florida, Daytona (Tiffany Coll.).

41. MOUGEOTIA HANDELII Skuja 1937. *Symbolae Sinicae.* **1**, p. 83, Fig. 11.

Vegetative cells about 35 μ x 70–175 μ; chromatophore platelike, with 8–14 scattered pyrenoids; conjugation scalariform; zygospores globose, 40–42 μ in diameter; spore wall olive-brown, scrobiculate on the inner side. (Pl. XVI, Fig. 6.)

China, Yünnanfu, altitude 5,800 feet, February 20, 1914.

42. MOUGEOTIA SANFORDIANA Tiffany 1934. *Trans. Amer. Micros. Soc.* **53**, p. 219, Fig. 58.

Vegetative cells 33–38 μ x 100–250 μ; chromatophores with numerous scattered pyrenoids; conjugation scalariform; zygospores in the conjugating tube, globose, 63–68 μ in diameter, or subglobose, 54–65 μ x 65–72 μ; spore wall yellow, scrobiculate; pits 2–3 μ in diameter and about the same distance apart. (Pl. XVI, Fig. 7.)

United States: Florida, Daytona (Tiffany Coll.).

43. MOUGEOTIA OBLONGATA Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 219, Fig. 38.

Vegetative cells 14–22 μ x 80–200 μ; chromatophore with 6–12(–16) pyrenoids in a single row; conjugation scalariform, often connecting several filaments; zygospores in the conjugating tubes, usually bilobate-ovoid, sometimes more cylindric with concave sides, 28–36 μ x 47–58 μ; spore wall yellow, sometimes finely punctate. (Pl. XVI, Fig. 8.)

United States: Florida, Fort Myers (Tiffany Coll.).

This species is the first of 6 species having cylindric spores with concave lateral walls. *M. opelousensis* has round pillbox-shaped spores and is the culmination of this series of spore forms.

44. MOUGEOTIA VARIANS (Wittrock) Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 79.

Vegetative cells 25–27 μ; chloroplasts with numerous scattered pyrenoids; conjugation scalariform; zygospores in the conjugating tubes, extending into or across the gametangia, cylindric-ovoid, usually with concave sides, ends convex, 48–60 μ x 64–78 μ; spore wall yellow-brown, smooth; sporangia adjoined by 2, 3, or 4 cell remnants. (Pl. XVI, Fig. 12.)

United States: Wisconsin (Prescott Coll.).

Sweden; Finland; Holland; Czechoslovakia.

45. Mougeotia angolensis W. & G. S. West 1897. *Jour. Bot.* 35, p. 39.

Vegetative cells 25–29 μ x 100–145 μ; chromatophores with 4–6 very small pyrenoids irregularly disposed; conjugation scalariform; zygospores in the conjugating tubes, short-cylindric with concave sides, 19–21 μ in diameter; wall smooth; gametangia slightly curved. (Pl. XVI, Fig. 16.)

Africa, Angola.

West's drawing of the spore may be misleading. The polar ends should be visualized as circular.

46. Mougeotia laetevirens (Braun) Wittrock 1877. Wittrock and Nordstedt Algae Exsiccatae, No. 58. *Bot. Notiser* 1877. p. 23.

Vegetative cells 35–40 μ x 65–350 μ; chromatophores with numerous scattered pyrenoids; conjugating cells geniculate; conjugation scalariform; zygospores in the conjugating tubes; outer wall short-cylindric, 36–47 μ x 45–72 μ, with concave sides; spore wall yellow-brown, smooth; aplanospores ovoid or obliquely ovoid. Spores quite variable in form. (Pl. XVI, Figs. 9–11.)

United States: Wisconsin and Indiana; eastward to Massachusetts and Florida.

Europe; South America; southern Siberia; India; China; Australia.

47. Mougeotia acadiana Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 224.

Vegetative cells 43–54 μ x 100–400 μ; chromatophores with many scattered pyrenoids; conjugating cells geniculate; conjugation scalariform; zygospores in the greatly enlarged conjugating tubes, cylindric-ovoid, usually with concave sides, ends convex, 51–70 μ x 57–78 μ; spore wall yellow, thick, smooth. Similar to *M. laetevirens* but larger in all dimensions.

United States: Mississippi and Florida.

Latvia (Skuja); Czechoslovakia (Czurda).

Some of the records for *M. laetevirens* probably belong to this larger species which it closely resembles.

48. Mougeotia opelousensis Taft 1944. *Ohio Jour. Sci.* 44, p. 238.

Vegetative cells 25–28 μ x 150–340 μ; chromatophores with 6–12 pyrenoids in a single row; conjugation scalariform; zygospores short-

cylindric, with concave ends and sides, formed in the tubes, 55–64μ x 30–34μ; spore wall yellow punctate; punctations about .8μ in diameter and evenly spaced over the entire wall. (Pl. XVI, Figs. 13–15.)

United States: Louisiana, Opelousas, 1938.

49. Mougeotia depressa (Hassall) Wittrock 1880. *Skandinaviens Vaxter.* 4, p. 23.

Vegetative cells 7–12μ x 35–144μ; conjugation scalariform and lateral; zygospores in the conjugating tubes, compressed-ellipsoid with the longer axis parallel to the filaments, 28–32μ x 12–14μ; spore wall brown, punctate. (Pl. XVII, Fig. 1.)

United States: Mississippi; Florida.

British Isles; Germany; Sweden; Luxemburg; Switzerland.

When the spores are immature there is a distinct pectic layer on the sporangium wall.

50. Mougeotia ovalis (Hassall) Nordstedt 1886. *Bot. Notiser* 1886. p. 136.

Vegetative cells 11–14μ x 110–140μ; conjugation scalariform; zygospores in the conjugating tubes, compressed-ovoid to subglobose, 29–38μ x 26–36μ; spore wall finely scrobiculate, brown. (Pl. XVII, Figs. 2–3.)

British Isles; Italy; Germany; Switzerland.

It seems probable that specimens will be found with a pectic layer on the sporangium walls.

51. Mougeotia pectosa Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 220, Figs. 53–54.

Vegetative cells 14.5–19μ x 120–190μ; chromatophores with 4–8 pyrenoids in a single row; conjugation scalariform, but less frequent than reproduction by aplanospores; zygospores in the conjugating tubes enclosed in a 5–10μ thick pectic sporangium wall, compressed-globose, 26–29μ x 20–22μ; spore wall colorless, smooth; aplanospores globose to compressed-globose, formed partly within or largely outside the mother cells, 18–21μ in diameter, when formed outside the mother cell covered with a pectic layer. Spores may not have been fully mature. (Pl. XVII, Figs. 4–6.)

United States: Florida (Tiffany Coll.).

52. Mougeotia gelatinosa Wittrock 1889. Wittrock and Nordstedt Algae Exsiccatae, No. 957.

Vegetative cells 12–18μ x 120–180μ; chromatophores with 3–6 pyrenoids in a single row; conjugation scalariform; zygospores in the conjugating tubes, compressed-ovoid, 38–47μ x 28–39μ, not including the

outer pectic layer, which may be 7–10μ in thickness; spore wall brown, smooth. (Pl. XVI, Fig. 17.)

British Isles; Sweden; Finland; Latvia; Spain.

53. Mougeotia disjuncta Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 222, Figs. 50–51.

Vegetative cells 14–18μ x 50–200μ; chromatophore with 2–8 pyrenoids in a line; conjugation scalariform; zygospores in the conjugating tubes, compressed-globose, 24–32μ x 21–28μ; sporangium wall changing during maturity to pectic substance and becoming as much as 25μ in thickness and pushing the 2 gametangia apart, but supporting the zygospore within; spore wall chestnut brown, punctate, suture prominent. (Pl. XVII, Figs. 7–8.)

United States: Florida, Fort Myers (Tiffany Coll.); China, Hunan (Jao 1940) listed as *M. gelatinosa.*

54. Mougeotia oedogonioides Czurda 1931. *Beih. Bot. Zentralbl.* **48**, p. 286.

Vegetative cells 16–18μ in diameter, with 1–2 platelike chromatophores, each with 2–3 pyrenoids; conjugation scalariform between geniculate cells, lateral by the solution of the cross wall and the development of a conjugating tube between the ends of the gametangia; subsequently, in both cases, following the union of the gametes, the sporangium wall changes to a thick pectic layer, 8–20μ in width; the gametangial wall at the point of union with the sporangium becomes modified, suggesting the ring scars of *Oedogonium* cells; zygospores globose or compressed-globose, 41–50μ x 40–41μ; outer wall thick, colorless, smooth; spore wall yellow, thick, and irregularly corrugate, with a distinct equatorial suture. (Pl. XVII, Figs. 9–10.)

Asia, Tibet.

55. Mougeotia cyanea Transeau 1926. *Ohio Jour. Sci.* **26**, p. 321.

Vegetative cells (14–)16–18(–20)μ x 160–200μ; chromatophore occupying one-third to one-half of the cell, with 4–10 pyrenoids in a row; conjugation scalariform; zygospores in the conjugating tubes, compressed-spherical, 38–48μ x 30–40μ, with the long axis parallel to the filaments; spore wall blue, finely punctate; aplanospores spheroidal, laterally placed in the sporogenous cell, 30–32μ in diameter; both kinds of spores surrounded at maturity with a transparent pectic layer, 4–8μ thick, which may disappear in preserved specimens. (Pl. XVII, Figs. 15–17.)

United States: Michigan and Ohio to Texas and Florida.

56. Mougeotia atubulosa Krieger 1941. *Rabenhorst's Kryptogamenflora.* 13 (2), p. 168.

Vegetative cells 19–21 μ x 100–140 μ; chromatophores with several pyrenoids in a row; conjugation scalariform; zygospores compressed-ovoid, 25–27 μ x 20–21 μ, with the longer axis parallel with the filaments, wholly within the conjugating tubes; at maturity the tube wall becomes a pectic wall 8–10 μ in thickness; spore wall blue, coarsely punctate; pits about .5 μ in diameter, 1–1.5 μ apart. (Pl. XVII, Figs. 13–14.)

Java, Dieng Plateau (B. Rensch Coll.).

57. Mougeotia operculata Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 220, Fig. 52.

Vegetative cells 18–21 μ x 60–285 μ; chromatophores with 4–8 pyrenoids, usually 4; conjugation scalariform; zygospores in the conjugating tubes, compressed-spheroid, 27–30 μ x 21–27 μ, with a prominent equatorial ridge and suture on the wall; spore wall pale yellow, shallow-scrobiculate. (Pl. XVII, Figs. 11–12.)

United States: Oklahoma; Mississippi; Florida.

58. Mougeotia pawhuskae Taft 1934. *Trans. Amer. Micros. Soc.* 53, p. 220.

Vegetative cells 18–22 μ x 90–170 μ; chloroplasts with 6–8 pyrenoids in a row; conjugation scalariform; zygospores in the conjugating tubes, compressed-globose, 34–40 μ x 25–32 μ, with the longer axis at right angles to the tubes, surrounded by a pectic layer 4–16 μ in thickness; spore wall yellow to yellow-brown, scrobiculate, with a distinct equatorial suture. (Pl. XVII, Figs. 24–25.)

United States: Oklahoma, Pawhuska, April 25, 1932.

59. Mougeotia seminoleana Tiffany 1934. *Trans. Amer. Micros. Soc.* 53, p. 220, Fig. 40.

Vegetative cells 20–25 μ x 70–200 μ; chromatophores with 4–12 pyrenoids in a row; conjugation scalariform; zygospores in the conjugating tubes, compressed-globose, 32–47 μ x 25–36 μ; outer sporangium wall a pectic layer 2–4 μ in thickness, absent from most of the mature spores; spore wall brown to dark chestnut brown, coarsely punctate, suture sometimes prominent, sometimes scarcely visible; aplanospores smaller, 20–22 μ x 25–29 μ, usually outside the mother cell, otherwise similar to the zygospores. (Pl. XVII, Fig. 22.)

United States: Florida, Fort Myers; Texas, Fredericksburg (Taft Coll.).

The last of the series with compressed-globose spores, which begins with *M. depressa* Number 49.

60. Mougeotia transeaui Collins 1912. *Tufts College Studies.* Sci. Ser. 3, p. 77. Wittrock. *Bih. Kgl. Svensk Vetensk. Akad. Handl.* 1, p. 39. 1872 (as *M. tenuis*).

Vegetative cells 9–13μ x 50–150μ; chromatophore with 4–8 pyrenoids in a single row; conjugation scalariform; zygospores globose to triangular-ovoid, 20–30μ x 26–36μ, occupying the middle portion of the receptive gametangium and the tube; spore wall yellow, smooth; aplanospores obliquely ovoid, 12–20μ x 20–32μ, formed at the middle of a straight or slightly angled cell which may be as long as the gametangium or longer. (Pl. XVII, Figs. 19–20.)

United States: Not uncommon from Oklahoma eastward to Massachusetts and Florida.

England; Sweden; India.

The first of a series of 3 species in which the sporangium divides one of the gametangia but not the other. In many collections of these species there are filaments in which only part of the cells conjugate; the others form aplanospores. Other collections contain only aplansporic filaments. Recently Krieger has listed this species as *M. abnorme* Kisselev 1927. The figure in Kisselev's publication of 1927 is probably of some other species, since the first structures formed after conjugation are the 3 sporangial walls, and this figure has no sporangial walls. The name *M. tenuis* Wittrock 1872 was preoccupied by *M. tenuis* Kützing 1849, which proved to be a synonym of *M. scalaris* Hassall 1842.

61. Mougeotia floridana Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 224.

Vegetative cells 14–20μ x 60–200μ; chromatophores with 6–8 pyrenoids in a single row; conjugation scalariform; zygospores occupying the middle of the receptive gametangia and the tubes, globose to triangular-ovoid, 30–40μ x 36–48μ; spore wall yellow, smooth; aplanospores obliquely ovoid, 18–24μ x 30–45μ, occupying the middle part of the cell; spore wall yellow, smooth.

United States: Oklahoma and Texas eastward to Pennsylvania and Florida.

Northern India (Randhawa Coll.).

This species was collected by Wolle at Bethlehem, Pennsylvania, and named *M. tenuis* (Cleve) Wittrock var. *minor.*

62. Mougeotia poinciana Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 224, Figs. 45–46.

Vegetative cells 21–25μ x 100–200μ; chromatophores with 6–10 pyrenoids in a single row; conjugation scalariform; zygospores occupying the middle portion of the receptive gametangia and the tubes, triangular-ovoid to globose, 36–44μ x 35–51μ; spore wall yellow, smooth;

aplanospores occupying the middle part of the cell; obliquely ovoid, 24–30μ x 32–48μ. (Pl. XVII, Fig. 21.)

United States: Florida, Daytona (Tiffany Coll.).

In Florida the 3 foregoing species were all found in the same pond. In none of the specimens studied was interspecific conjugation observed.

63. Mougeotia caimani Transeau 1938. *Amer. Jour. Bot.* **25**, p. 525, Fig. 2.

Vegetative cells 4–5μ x 60–100μ; chromatophores with 2–8 pyrenoids in a single row; conjugation scalariform; zygospores dividing both gametangia, subglobose, 20–25μ in diameter, surrounded by a thin pectic layer. Zygospores seen were smooth and colorless. They may not have been mature, but the dimensions of the filaments and the zygospores distinguish it clearly from all described species. (Pl. XVII, Fig. 18.)

Haiti, Trou Caiman (R. M. Bond Coll.).

After conjugation the filaments form a tangled meshwork, since they bend in all directions during conjugation.

64. Mougeotia cherokeana Taft 1934. *Trans. Amer. Micros. Soc.* **53**, p. 222, Fig. 39.

Vegetative cells 7–9μ x 90–120μ; chromatophores with 2–6 pyrenoids in a single row; conjugation scalariform; zygospores filling the tube and dividing both gametangia, globose, rarely subglobose, 21–25μ in diameter, surrounded by an outer pectic layer 4–6μ in thickness; spore wall yellow to brownish-yellow, smooth. (Pl. XVII, Fig. 23.)

United States: Oklahoma, Wichita Mountains, April 29, 1932.

65. Mougeotia americana Transeau 1918. *Tech. Pub.,* No. 9. New York State College of Forestry, p. 237.

Vegetative cells 4–5μ x 40–120μ; chromatophores with 4–10 pyrenoids in a single row; conjugating cells slightly or strongly geniculate; zygospores dividing both gametangia, irregularly quadrate with concave or convex sides; angles produced and truncate, the space between the zygospore and the sporangium walls being filled with pectic material; spores 13–24μ x 18–32μ; wall colorless, smooth, transparent; aplanospores obliquely elliptical, ends truncate at the middle of very long genuflexed vegetative cells, 10–14μ x 20–26μ. (Pl. XVIII, Figs. 1–3.)

United States: Michigan; New York; Florida.

66. Mougeotia corniculata Hansgirg 1886. *Oesterr. Bot. Zeitschr.,* No. 10.

Vegetative cells 5–7μ x 30–180μ; conjugation scalariform; sporangia dividing both gametangia; zygospores quadrately ovoid, 22–26μ x

22–26 μ; spore wall yellow-brown, smooth, thickened, forming rounded processes at the angles. (Pl. XVIII, Figs. 4–5.)

From France to Czechoslovakia, and North Africa.

The figure published by Hansgirg is incorrect in that chromatophores were drawn in the unoccupied halves of the gametangia.

67. Mougeotia thylespora Skuja 1929. *Acta Horti Bot. Univ. Latviensis.* 4, p. 48.

Vegetative cells 5–8 μ x 25–80 μ; chromatophore with 4–8 pyrenoids in a single row; conjugating cells geniculate; conjugation scalariform; sporangia dividing both gametangia; zygospores quadrangular with angles produced and truncate, 16–22 μ x 20–32 μ; spore wall yellow-brown, scrobiculate, with tumid sides and rounded projecting corners; aplanospores oblique-ellipsoid, 18–25 μ x 28.8–39.6 μ. (Pl. XVIII, Figs. 6–8.)

United States: Florida (Tiffany Coll.).

Estonia.

68. Mougeotia uberosperma W. & G. S. West 1897. *Jour. Bot.* 35, p. 37.

Vegetative cells 6–8 μ x 24–64 μ; conjugation scalariform; zygosporangium dividing both gametangia; zygospores angular-globose (4–6 angles), wall very thick and lamellate, smooth and colorless, with corners extended into 4 solid, unequal processes which project into the gametangia; zygospores 21–27 μ in diameter, processes 3–18 μ long; aplanospores 20 μ x 30 μ with 2 processes. (Pl. XVIII, Figs. 9–10.)

Africa, Angola and Kentani.

69. Mougeotia craterophora Bohlin 1901. *Bih. Kgl. Svensk Vetensk. Akad. Handl.* 27, p. 50.

Vegetative cells 7–9 μ in diameter (8–14 diameters long); conjugation scalariform; zygospores in the conjugating tubes, or dividing one, or both, gametangia; zygospores globose to ovoid, 18–22 μ x 24–28 μ, with 2 to 4 crateriform or retuse processes; spore wall brown, smooth. (Pl. XVIII, Figs. 11–14.)

Azores.

70. Mougeotia irregularis W. & G. S. West 1897. *Jour. Bot.* 35, p. 38.

Vegetative cells 13.5–15 μ x 70–90 μ; conjugation scalariform; conjugating cells more or less recurved; sporangium dividing both gametangia; zygospores irregularly quadrate to trapezoid with concave sides and thick walls, 38–63 μ x 42–48 μ including the processes, angles

with hornlike processes of varying length with rounded ends; spore wall thick, yellow to yellow-brown, punctate. (Pl. XVIII, Figs. 15–16.)

Africa, Angola.

71. Mougeotia granulosa Transeau 1938. *Amer. Jour. Bot.* 25, p. 525.

Vegetative cells 14.4–18 μ x 140–180(–320) μ with 4 to 8 pyrenoids in a row; conjugation scalariform; sporangium wall thick, transparent, dividing both gametangia, varying from broadly ovoid to quadrangular-ovoid; spores 36–47 μ x 42–52 μ; walls yellow to brown, rarely smooth, mostly granulose when mature, either apparently single or distinctly double—both layers granulose when separated. (Pl. XVIII, Figs. 18–20.)

South Africa, Cape Town, Cape Flats (E. Stephens Coll.).

72. Mougeotia capucina (Bory) Agardh 1824. *Systema Algarum,* p. 84.

Vegetative cells 14–21 μ x 70–280(–340) μ, usually violet colored; 1 or 2 chromatophores either rod-shaped occupying one-third to one-fourth of the cell with 4–8 pyrenoids, or ribbonlike occupying three-fourths of the length of the cell with 12–16 μ pyrenoids in a single row; conjugation scalariform; the first sporangium walls are formed at a distance (5–52 μ) from the zygospore, the intervening space filled with pectic compounds; sporangium divides both gametangia; zygospores irregularly quadrangular with concave sides, 50–70 μ x 60–100 μ; spore wall violet to brown, thick especially at the angles, smooth; aplanospores not uncommon, 20–36 μ x 45–70(–80) μ, with more or less produced ends. (Pl. XVIII, Figs. 26–31.)

United States: Wisconsin; Michigan; New York; North Carolina; Alabama; Florida.

Widely distributed in Europe; Central Africa; northern South America; Hawaii; New Zealand.

In some collections there are double spores that are the result of division of gametes just prior to conjugation. If conjugation fails in one or both pairs of gametes there may be one or more parthenospores instead of 2 zygospores. At Tupper Lake, in the Adirondacks, September, 1936, a specimen was found with a mature zygospore formed by scalariform conjugation between 2 adjacent cells of a filament. (Pl. XVIII, Fig. 31.)

73. Mougeotia delicata Beck 1926. *Archiv f. Protist.* 55, p. 179, Fig. 17.

Vegetative cells about 3.5 μ in diameter; conjugation scalariform; sporangia dividing both gametangia; zygospores cruciate-quadrate,

with concave sides, angles with hornlike processes; spores about 28 μ on a side. (Pl. XVIII, Fig. 17.)

Austria, Kärnten.

74. Mougeotia elegantula Wittrock 1872. *Om Gotland och Oelands Söt. Alg.*, p. 40.

Vegetative cells 3.5–5 μ x 50–135 μ; chromatophore with 4–8 pyrenoids in a row; conjugating cells geniculate; conjugation scalariform; sporangium dividing both gametangia; zygospores cruciate-quadrate, 18–24 μ x 18–24 μ, with rounded corners; spore wall hyaline, smooth; aplanospores ellipsoid, 6–9 μ x 20–24 μ, otherwise similar to the zygospores. (Pl. XVIII, Figs. 21–22.)

United States: Wisconsin; Iowa; Texas eastward to Massachusetts.

Widely distributed in Europe; China, Yünnan; West Indies.

At Twin Lakes, Michigan, a specimen was collected in which a zygospore had been formed by scalariform conjugation between 2 cells of the same filament, which had been bent into a loop.

75. Mougeotia boodlei (W. & G. S. West) Collins 1912. *Tufts College Studies.* **3** (2), p. 76.

Vegetative cells 4–5.5 μ x 25–225 μ; chromatophore .5–.8 of the length of the cell, with 4–6 pyrenoids in a single row; reproduction usually by aplanospores, very rarely by zygospores; conjugation scalariform; zygospores quadrangular, 15–18 μ x 15–23 μ, corners somewhat rounded; aplanospores ellipsoid, 12–15 μ x 23–25 μ, projecting slightly on the convex side of the slightly curved sporangia; spore wall yellow to brown, punctate. (Pl. XVIII, Figs. 23–25.)

United States: Illinois, Charleston; Oklahoma (Taft Coll.).

British Isles.

Very abundant for several years in a lily pond on the campus of the Eastern Illinois State Teachers College at Charleston, Illinois; fruited there both in the spring and autumn months. Among the hundreds of aplanospores examined perhaps a total of 25–30 zygospores was found. The Oklahoma specimens had spores darker than the Illinois specimens.

76. Mougeotia gracillima (Hassall) Wittrock 1872. *Bih. Kgl. Svensk Vetensk. Akad. Handl.* **1**, p. 40.

Vegetative cells 5–7 μ x 55–140 μ; conjugation scalariform; sporangia dividing both gametangia; zygospores quadrate, with deeply concave sides, 20–25 μ x 20–28 μ, angles retuse; spore wall minutely verrucose; aplanospores spindle-shaped. (Pl. XIX, Figs. 1–2.)

United States: Texas; Michigan; Illinois to New York and Massachusetts.

Europe, generally distributed throughout.

77. Mougeotia viridis (Kützing) Wittrock 1872. *Bih. Kgl. Svensk Vetensk. Akad. Handl.* 1, p. 39.

Vegetative cells 6–9 μ x 40–160 μ; chromatophores occupying most of cell with 2–6 pyrenoids in a single row; conjugation scalariform; sporangia dividing both gametangia; zygospores quadrate with concave sides and retuse angles, 20–32 μ x 20–32 μ; spore wall smooth, colorless; aplanospores oblique-ellipsoid, 14–16 μ x 30–36 μ. (Pl. XIX, Figs. 3–4.)

United States: Wisconsin; Illinois to New Jersey and Florida.

Europe, generally distributed; North Africa; India; China, Szechwan.

78. Mougeotia producta G. S. West 1907. *Ann. Roy. Bot. Gard., Calcutta.* 6, Part 2.

Vegetative cells 7–8 μ x 84–160 μ; conjugation scalariform; sporangia dividing both gametangia; zygospores quadrangular, with concave or slightly convex sides, angles produced and truncate, 29–37 μ on a side; spore wall "colorless," punctate; aplanospores obliquely ellipsoid with ends produced, 14–18 μ x 30–40 μ, otherwise similar to the zygospores. (Pl. XIX, Figs. 5–6.)

Burma and Assam.

Near the ends of the aplanospores there is a ringlike thickening of the outer spore wall.

79. Mougeotia regellii Skuja 1937. *Hedwigia.* 77, p. 53, Pl. 2, Figs. 1–3.

Vegetative cells 7–9 μ x 50–160 μ; chromatophores sometimes constricted in the middle, with 2–4 pyrenoids in a row; conjugation scalariform; conjugating cells slightly geniculate; zygospores dividing both gametangia, hexagonal-ovoid, 22–25 μ x 29–30 μ; spore wall thin, yellow-brown, smooth; inner wall colorless to pale yellow, densely and finely punctate. (Pl. XIX, Figs. 7–8.)

Greece, Taygetus.

80. Mougeotia tumidula Transeau 1914. *Amer. Jour. Bot.* 1, p. 297.

Vegetative cells 6–8.5 μ x 70–120 μ; chromatophore with 4–8 pyrenoids; conjugation scalariform; sporangia dividing both gametangia; zygospores quadrangular, with convex walls, 22–26 μ x 26–30 μ, angles retuse; spore wall colorless, distinctly punctate; aplanospores obliquely ellipsoid, 12–14 μ x 28–32 μ, with retuse ends and coarsely punctate. (Pl. XIX, Figs. 9–10.)

United States: Illinois; Wisconsin; Iowa; Arkansas, eastward to New York.

Puerto Rico.

Differs from *M. punctata* in having zygosporangia with convex lateral walls and smaller dimensions.

81. Mougeotia austriaca Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 90, Fig. 82.

Vegetative cells 7–9 μ x 50–140 μ; chromatophores with 2 pyrenoids; conjugation scalariform; zygospores quadrangular, with concave sides and rounded corners bulging into the gametangia, 20–25 μ x 27–30 μ; spore wall golden-brown, thick, scrobiculate; pits about 1 μ in diameter. (Pl. XIX, Figs. 11–12.)

United States: Texas (Taft Coll.).

Austria, Wiener-Neustadt.

82. Mougeotia virescens (Hassall) Borge 1913. *Süsswasserflora Deutschland.* 9, p. 43.

Vegetative cells 8–9 μ x 50–220 μ; conjugation scalariform; sporangia dividing both gametangia; zygospores quadrangular, with concave sides, 29–35 μ x 29–35 μ; wall colorless, smooth, with rounded corners. (Pl. XIX, Fig. 16.)

United States: Wisconsin (Prescott Coll.).

Canada, Maritime Provinces (Hughes Coll.); England; Germany; France to Yugoslavia; China, Yünnan (Li Coll.), and Szechwan (Jao Coll.).

83. Mougeotia rotundangulata Jao 1935. *Sinensia.* 6, p. 579, Pl. 2, Figs. 45–46.

Vegetative cells 8–10 μ x 160–420 μ; chromatophores with 8–14 pyrenoids in a single row; conjugation scalariform; sporangia dividing both gametangia; zygospores quadrangular, somewhat tumid, 32–35 μ x 32–35 μ, with rounded angles; wall scrobiculate with scattered pits, 1–2 μ in diameter, colorless at maturity. (Pl. XIX, Figs. 13–14.)

China, Szechwan.

84. Mougeotia punctata Wittrock 1867. *Algologiska Studier.* I. Uppsala.

Vegetative cells 8–10 μ x 50–120 μ; chromatophores with 4 pyrenoids in a row; conjugation scalariform; sporangia dividing both gametangia; zygospores quadrangular with concave sides and obtuse or retuse angles, 30–38 μ x 30–38 μ, 18–20 μ thick; outer wall finely scrobiculate, inner nearly smooth. (Pl. XIX, Fig. 15.)

United States: Wisconsin (Prescott Coll.); Florida (Tiffany Coll.).

Sweden, Upland; Brazil (Drouet Coll.).

Jao has recently described (*Bot. Bull. Acad. Sinica.* I, p. 101, 1947) a new species, *M. subpunctata,* that closely resembles this species, but the cell diameters are 5–6.5 μ and the spores are 20–25 μ x 18–25 μ.

85. Mougeotia quadrangulata Hassall 1843. *Ann. and Mag. Nat. Hist.* **11**, p. 434.

Vegetative cells 8–13μ x 50–140μ; chromatophore with 8–16 pyrenoids in a single row; conjugating cells geniculate; conjugation scalariform; sporangia dividing both gametangia; zygospores quadrangular with straight sides and truncate corners or rarely with angles retuse, 28–40μ x 28–40μ; spore wall colorless, punctate; aplanospores obliquely ovoid, 20–21μ x 36–44μ. (Pl. XIX, Figs. 19–20.)

United States: Illinois to Louisiana eastward to Newfoundland; Massachusetts; Florida.

Generally distributed from England to Russia and China; south to North Africa and Madagascar; South America, Chile.

86. Mougeotia paludosa G. S. West 1899. *Jour. Bot.* **37**, p. 108, Pl. 395, Figs. 4–6.

Vegetative cells 11.5–13.5μ x 70–185μ; chromatophores short, occupying about one-third the length of the cell, with 4–6 pyrenoids in a single row; fertile cells recurved; conjugation scalariform; sporangia dividing both gametangia; zygospores ovoid to quadrangular-ovoid, angles undulate truncate, 32–28μ x 44–49μ; outer wall of zygospores thick, smooth; inner wall smooth, thin. (Pl. XIX, Figs. 17–18.)

England.

87. Mougeotia aspera Woronichin 1923. *Notulae Syst. Inst. Crypt. Hort. Bot. Petrop.* **2**, p. 192.

Vegetative cells 13–16.5μ x 78–112μ; conjugation scalariform; sporangia dividing both gametangia; zygospores globose, 36–46μ in diameter, rarely ovoid, 46μ x 66μ; spore wall pale brown, punctate.

Asia Minor, Tiflis; Finland.

88. Mougeotia fragilis (Zeller) de Toni 1889. *Sylloge Algarum.* 1 (2), p. 721.

Vegetative cells 17–22μ x 85–200μ; conjugation scalariform; zygospores quadrangular, 22–28μ x 22–28μ; spore wall smooth.

Burma, Pegu.

89. Mougeotia tenerrima G. S. West 1914. *Mem. Soc. Neuchateloise Sci. Nat.* **5**, p. 1028.

Vegetative cells 4–5μ x 110–135μ; chromatophores with 6 pyrenoids in a single row; zygospores unknown; aplanospores oblique-ellipsoid, 12–13μ x 24–25μ, ends slightly mammillate, wall smooth. (Pl. XIX, Figs. 30–31.)

South America, Colombia.

90. Mougeotia tropica (W. & G. S. West) Transeau 1926. *Ohio Jour. Sci.* **26**, p. 325, Pl. 7, Fig. 112.

Vegetative cells $6–7\mu$ x $36–56\mu$; chromatophore with 2 pyrenoids; zygospores unknown; aplanospores obliquely globose with projecting mammillate solid processes, wall yellow-brown, scrobiculate, $27–28\mu$ x $27–29\mu$, with the processes $42–46\mu$ in length. (Pl. XIX, Fig. 21.)

Africa, Angola.

91. Mougeotia miamiana Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 222, Pl. 19, Figs. 41–42.

Vegetative cells $6–7.2\mu$ x $60–130\mu$; chromatophores with 2–6 pyrenoids; zygospores unknown; aplanospores formed in the middle of straight or slightly angled cells; outer sporangium wall covered at all stages by a pectic layer; aplanospores globose to ovoid to ellipsoid with projections at either end; globose spores $18–20\mu$ in diameter, ellipsoid spores $16–18\mu$ x $25–32\mu$; spore wall yellow, punctate. (Pl. XIX, Figs. 22–23.)

United States: Oklahoma, Miami, August 14, 1932 (Taft Coll.).

92. Mougeotia ventricosa (Wittrock) Collins 1912. *Tufts College Studies.* **3**, p. 76.

Vegetative cells $6–9\mu$ x $100–140\mu$; chromatophores with about 4 pyrenoids in a single row; zygospores unknown; aplanospores obliquely ellipsoid to subglobose, $12–24\mu$ x $16–29\mu$; spore wall smooth, yellow-brown. (Pl. XIX, Fig. 24.)

United States: Reported from California, Michigan, and Pennsylvania. Have seen no specimens.

Sweden; Latvia.

93. Mougeotia prona Transeau 1926. *Ohio Jour. Sci.* **26**, p. 326, Pl. 7, Figs. 109–11.

Vegetative cells $8–12\mu$ x $60–140(–280)\mu$; chromatophores 2 with the nucleus between, pyrenoids 4–6 in each; zygospores unknown; aplanospores obliquely ellipsoid with ends produced and truncate, $20–24\mu$ x $50–52(–60)\mu$; spore wall faintly yellow, punctate, with rounded or retuse ends. (Pl. XIX, Figs. 26–28.)

United States: New York, High Hill, Long Island, growing in a roadside spring.

During the formation of an aplanospore an enlargement of the middle portion of the cell develops. Simultaneously the protoplast begins to contract and the 2 chromatophores move into the enlargement, 1 on each side of the nucleus. The contracted protoplast is cut off from the 2 narrow parts of the sporogenous cell by cross walls. A little later the spore wall develops. Similar stages have been seen in other species of *Mougeotia.*

94. Mougeotia mayori (G. S. West) Transeau 1926. *Ohio Jour. Sci.* **26**, p. 327. G. S. West. *Mem. Soc. Neuchateloise Sci. Nat.* **5**, p. 1027.

Vegetative cells 13–15μ x 235–315μ; chromatophore with 11–14 pyrenoids in an irregular row; zygospores unknown; aplanospores obliquely ellipsoid with truncate ends, 24–26μ x 34–38μ; spore wall yellow, punctate. (Pl. XIX, Fig. 29.)

South America, Colombia.

95. Mougeotia rava Transeau 1944. *Ohio Jour. Sci.* **44**, p. 244.

Vegetative cells 8–12μ x 32–120μ; chromatophore with 4–8 pyrenoids in a row; reproducing by aplanospores which are formed mostly outside the recurved sporiferous cells; aplanospores globose, 16–20μ in diameter; wall gray-brown and smooth. (Pl. XIX, Fig. 25.)

United States: Mississippi, Starkville; Louisiana, Alexandria (Hicks Coll.); Texas, Austin (Taft Coll.).

The species resembles certain aplanosporic filaments of *M. calcarea.* The metallic gray-brown color of the spores is distinctive, also the absence of conjugation.

SPECIES NOT IN PROPER SEQUENCE

96. Mougeotia subpaludosa Ley 1944. *Sinensia.* **15**, p. 97.

Vegetative cells 9–11μ x 30–152μ; pyrenoids 2; conjugation scalariform; sporangia dividing both gametangia; zygospores quadrangular-ovoid, sometimes much rounded, 25–29μ x 21–29μ, 20–27μ thick; spore wall very thick, smooth, deep yellow at maturity. (Pl. XIX, Fig. 32.)

China, Woo-Yang-She, northern Kwangtung, February 21, 1942.

Resembles Number 86, *Mougeotia paludosa* West, but differs in smaller dimensions throughout.

97. Mougeotia chlamydata Prescott 1947. *Ohio Jour. Sci.* **47**, p. 130.

Vegetative cells 12–16μ x 200–240μ; chromatophores with 4–6 pyrenoids in a row; conjugation scalariform; zygospores compressed-globose, 26–28μ x (30–)32–38μ; sporangium wall bluish (by refraction), spore wall thick, metallic green, and smooth. The sporangium wall is quite unique in that after conjugation it has an inner and outer layer of cellulose separated by a thick pectic layer. The outer layer disintegrates equatorially as the spore reaches maturity and the pectic layer dissolves leaving a collar around the base of each half of the conjugating tube. (Pl. XIII, Fig. 19.)

Ecuador, volcano Cotopaxi, hanging bog at 14,000 feet.

Should be near *M. cyanea,* Number 55. The spore is compressed at right angles to the conjugating tube.

98. MOUGEOTIA COTOPAXIENSIS Prescott 1947. *Ohio Jour. Sci.* 47, p. 132.

Vegetative cells 10–16μ x 80–250μ; chromatophores with 2–4 pyrenoids in a row; conjugation scalariform; zygospores globose or compressed at right angles to the short conjugating tubes, 30–32μ in diameter; spore wall steel-blue, scrobiculate with pits about 1μ in diameter, 4–5μ apart; sporangium wall thin, smooth. (Pl. XIII, Fig. 20.)

Ecuador, volcano Cotopaxi, hanging bog at 14,000 feet.

Should be near *M. cyanea,* Number 55.

99. MOUGEOTIA KWANGSIENSIS Jao 1947. *Bot. Bull. Acad. Sinica.* 1, p. 100.

Vegetative cells 12–13μ x 115–313μ; chromatophores with 4 to 6 pyrenoids in a single row; gametangia geniculate; zygosporangia dividing both gametangia, compressed-globose; zygospores, 35–42μ x 33–35μ; outer spore wall thick, lamellose, and hyaline; spore wall yellow, either smooth, or with thin reticulate wrinkles. It is possible that the wrinkles are due to contraction and are not morphological structures.

China, Suijen, common in rice fields.

Should be placed near *M. cherokeana* (No. 64), which is similar but smaller.

LIST OF THE SPECIES OF MOUGEOTIA WITH NUMBER

acadiana Transeau 1934 47
adnata Iyengar 1932 9
africana (G. S. West) Transeau 1944 17
americana Transeau 1918 65
angolensis W. & G. S. West 1897 45
angusta (Hassall) Kirchner 1878 1
areolata Transeau 1934 30
aspera Woronichin 1923 87
atubulosa Krieger 1941 56
austriaca Czurda 1932 81
boodlei (W. & G. S. West) Collins 1912 75
caelestis Transeau 1934 24
caimani Transeau 1938 63
calcarea (Cleve) Wittrock 1872 5
capucina (Bory) Agardh 1824 72
cherokeana Taft 1934 64
chlamydata Prescott 1947 97
corniculata Hansgirg 1886 66
cotopaxiensis Prescott 1947 98
crassa (Wolle) de Toni 1889 23

CHAPTER TEN

THE GENUS TEMNOGAMETUM W. & G. S. WEST 1897

The vegetative cells and filaments of the species resemble those of *Mougeotia.* The cells are cylindric, five to twenty-five diameters long, each with a single axile platelike chromatophore. The pyrenoids are arranged either several in a single row, or are numerous and scattered. The cell sap in 2 of the species is purple.

The behavior during reproduction is very different from that of the species of *Mougeotia.* The gametangia are short specialized cells formed at the ends of scattered vegetative cells. They are one to two diameters long and are gorged with starch and other food substances. In scalariform conjugation the adherent sides of two gametangia become distended and a hole develops within the ring of contact. These connecting walls widen and become the lateral walls of the quadrangular sporangium. Note that distinct conjugating tubes are not formed as in *Mougeotia.* In lateral conjugation, two adjoining gametangia of the same filament enlarge most at the separation wall, and the wall gradually disappears. The gametes unite and the zygospore is obliquely spindle-shaped. Aplanospores and parthenospores may be formed from the reproductive cells. Only 4 species have been found—all within the tropics.

Key to the Species of TEMNOGAMETUM

1. Chromatophores with pyrenoids in a row 2
1. Chromatophores with scattered pyrenoids .... 4. *T. thaxteri*
   2. Cell diameter 10–12μ, zygospores (lateral conjugation) 20–40μ x 40–60μ .... 1. *T. uleanum*
   2. Cell diameter 14–17μ, zygospores (lateral conjugation) 20–26μ x 61–67μ .... 2. *T. heterosporum*
   2. Cell diameter 14–20μ, zygospores (lateral conjugation) 35–42μ x 80–100μ .... 3. *T. transeaui*

Descriptions of Species

1. Temnogametum uleanum (Möbius) Wille 1909. *Pflanzenfamilien, Nachträge zum I Teil,* 2 abt., p. 13, Fig. 3. Möbius. *Hedwigia.* 34, p. 175, Pl. 2, Figs. 1–10. 1895.

Vegetative cells 10–12μ x 60–120μ, with an axile chromatophore with about 4 pyrenoids, cell sap purple; cells elongating to 20–25 diameters at time of conjugation; conjugation usually lateral, sometimes scalariform; gametangia 20–30μ long; zygospores by lateral conjugation obliquely ovoid, 20–40μ x 40–60μ; zygospores by scalariform conjugation quadrangular with truncate angles, 25–40μ x 30–50μ; spore walls transparent and smooth. Aplanospores rare but present. (Pl. XX, Figs. 1–4.)

Brazil, near Itajahi, March, 1894 (E. Ule Coll.).

2. Temnogametum heterosporum W. & G. S. West 1897. *Jour. Bot.* 35, p. 37, Pl. 370, Figs. 5–9.

Vegetative cells 14–17μ x 90–200μ; chromatophores with 2–6 pyrenoids, color of cell sap unknown; conjugation scalariform and lateral; gametangia 22–40μ in length; zygospores by scalariform conjugation quadrangular with concave sides, 39–50μ x 48–59μ; zygospores by lateral conjugation obliquely ovoid, 20–26μ x 61–67μ spore wall smooth, transparent. (Pl. XX, Fig. 10.)

Africa, Angola, Morro de Lopollo, February, 1860 (Welwitsch Coll.).

3. Temnogametum transeaui Prescott 1947. *Ohio Jour. Sci.* 47, p. 132.

Vegetative cells 14–20μ x 100–400μ, with a narrow, axial chromatophore with 2–4 pyrenoids in a row; conjugation lateral and scalariform; gametangia, 20–22μ x 20–30μ at the ends of vegetative cells; zygospores by lateral conjugation obliquely ovoid, 35–42μ x 80–100μ; zygospores by scalariform conjugation, 40–50μ x 45–60μ; median wall smooth, orange-brown at maturity. (Pl. XX, Figs. 5–6.)

Ecuador, volcano Cotopaxi, hanging bog at 14,000 feet.

4. Temnogametum thaxteri Transeau 1932. *Ohio Jour. Sci.* 32, p. 489, Pl. 1, Figs. 14–20.

Vegetative cells 39–45μ x 220–360μ; chromatophore broad with 30–120 pyrenoids scattered throughout; conjugation scalariform; gametangia 36–90μ long; zygospores quadrangular-ovoid, 60–75μ x 90–120μ, occasionally in pairs which are somewhat longer and narrower; lateral walls concave; aplanospores tumid, about 60μ x 75μ. (Pl. XX, Figs. 7–9.)

Trinidad, Cumuto Station, April 10, 1913 (Thaxter Coll.).

The cell sap in this species is purple.

CHAPTER ELEVEN

THE GENUS SIROCLADIUM RANDHAWA 1941

This tentative genus is established on the basis of chromatophores which resemble those of *Mougeotia,* and reproductive structures quite similar to those of *Sirogonium.* The vegetative cells are cylindric but variously curved, with plane end walls. The chromatophores are two broad parietal plates, each with several pyrenoids in a row, and the nucleus is supported by a cytoplasmic pillar between the flat sides of the chromatophores. The gametangia may become organized after an unequal division of a vegetative cell, or from a short undivided vegetative cell. Conjugation occurs between reflexed gametangia in adjacent filaments. Adhesion is followed by the growth of a pectic ring about the area of contact, but without the formation of tubes. The one known species is terrestrial and has rhizoids extending into the soil both as elongated basal cells and as outgrowths from other cells of a filament.

Description of Species

Sirocladium kumaoense Randhawa 1941. *Bot. Gaz.* **103**, p. 196.

Vegetative cells cylindric, more or less irregularly bent, with plane end walls, 45–64μ x 120–210μ; chromatophores 2; parietal plates 15–20μ broad, each with 4 to 12 large pyrenoids arranged in a row. The nucleus is centrally supported by a cytoplasmic pillar between the 2 chromatophores. Conjugation occurs between 2 geniculate gametangia without the formation of tubes. Receptive gametangia become inflated, zygospores are broadly ellipsoid, 42–70μ x 90–108μ; median spore wall yellow-brown and smooth. Parthenospores and aplanospores smaller and rounded, otherwise similar. (Pl. XX, Figs. 11–14.)

India, Upper Punjab, Almora, September and October, 1939. Found growing on moist clay on a ledge near a waterfall in the Kumaon Hills.

Specimens of this remarkable plant have been examined by the author. The width of the chromatophores and the size of the pyrenoids are quite unlike any specimens of *Sirogonium* that I have seen. That it has certain features in common with this latter genus is unquestionable. In the specimens seen there was no evidence of spiral twisting of the chromatophores. It is possible that in the living material the chromatophores were even wider than the dimensions given above.

CHAPTER TWELVE

THE GENUS ENTRANSIA ELWYN HUGHES 1943

The genus *Entransia* was established to classify an alga having simple filaments with cylindrical cells and one or two laminate parietal chromatophores extending lengthwise of the cell, with several irregular fingerlike processes extending outward and part way around the cell. Each chromatophore has several scattered pyrenoids. In young cells with a single chromatophore the nucleus is laterally placed near the center of the chromatophore. In mature cells the nucleus is in the bridge between the two chromatophores. The orientation of the two chromatophores with the nucleus between, the scattered pyrenoids, and the fingerlike processes extending outward and more or less enclosing the cell contents suggest that the plant may belong to the Zygnemataceae. On the other hand it may belong to the Ulotrichaceae near the genus *Ulothrix*. Until the reproductive structures are found no definite disposition of the genus can be made. Named for E. N. Transeau.

Description of Species

Entransia fimbriata Hughes 1943. *Abstracts of Doctoral Dissertations,* The Ohio State University, **40**, pp. 153–59; also in *Amer. Jour. Bot.,* **35** (1948), p. 487.

Filaments with cylindrical vegetative cells 19–22.4μ x 16–64μ; 1 or 2 parietal chromatophores extending lengthwise of the cell, each with several lateral processes partly embracing the cell contents. There is a nucleus, in young cells located laterally and near the center of the chromatophore; in mature cells with 2 chromatophores the nucleus is in the bridge between them. (Pl. XX, Fig. 15.)

Canada, Nova Scotia, Queens County, Charleston, July, 1941. Collected in a small artificial lake in the Port Medway River valley.

Here is an interesting note. In this same lake Hughes collected 3 new species of *Bulbochaete,* 1 new *Oedogonium,* and a new *Spirogyra.* These were the only new species of filamentous algae found on the peninsula during two summer collecting trips, and in the examination of numerous collections made by other residents of Nova Scotia. Many other collectors have had similar experiences of finding one station that contained several new or rare species not met with elsewhere in the same region during a collecting period of several years.

CHAPTER THIRTEEN

THE GENUS SPIROGYRA LINK 1820

The species of *Spirogyra* are known to more people than those of any other genus of the filamentous green algae. For many years they have been seen and named in biology classes in secondary schools and colleges. They occur on all the continents and larger islands in fresh-water ponds, streams, and lakes. Among the filamentous green algae the genus *Spirogyra* ranks next to *Oedogonium* in the number of described species.

In the following pages, 275 species are described, and it is highly probable that this number will be greatly increased as soon as habitats are visited repeatedly and collections are made by trained personnel. Most of our present knowledge is based on chance collections. Since we know that the fruiting period of many species is less than a fortnight, only repeated visits to the same station possibly can secure identifiable specimens of all the species present.

Professor Jean Massart once remarked, "Why waste your time on Spirogyras—there are no species in that genus." It is true that there are some highly variable species among them, but I suspect that most of the species will be found to be remarkably uniform when once they have been described adequately. The older descriptions were quite incomplete and gave few details concerning spore walls, conjugating tubes, and even spore forms. Consequently, many diverse specimens were classified as belonging to the same species.

The filaments of the *Spirogyras* are composed of cylindric cells, all very much alike except the first or basal cell which may develop as a rhizoid and anchor the filament at least during its early development. The vegetative cells of larger species often appear barrel-shaped under the microscope, and have been thus described and figured. This appearance usually is due to the pressure of the cover glass. Measurements of the diameters of vegetative cells should be made at the partition walls. Czurda

insists that cell lengths are of no taxonomic importance since they may be modified in some species by environmental conditions. Nevertheless there are some species in which the cells are relatively short (one-half to two diameters), and others in which they are relatively long (eight to twenty-five diameters). In these species at least, the cell lengths may be contributory evidence to their identification. Cells 600μ long have been seen in at least 5 species, the diameters of which are between 20μ and 45μ.

The chromatophores are ribbonlike or troughlike, with or without a median ridge, arranged in a left-handed, or counterclockwise spiral in the parietal cytoplasm. The number of spirals in a cell may vary from one to sixteen. In some species the number of chromatophores is uniform. In others there are occasional cells in filaments with one more than the usual number—particularly in the one-spiraled species. How these arise is not known. In still other species the number regularly varies within certain limits.

In determining the number of chromatophores in a given specimen, counts should be made only in filaments attached to the sporangia or gametangia being studied, as there may be vegetative filaments of nearly the same dimensions but of another species present in any collection. In most species the number of spirals is readily determined by focusing just below an upper-half turn of the spiral, counting this turn as one and adding to it the number of optical intersections made by the spirals on the opposite side of the cell. In very large species and in those with tightly coiled chromatophores this may be impossible. In such species and in those with nearly straight chromatophores, the numbers are best determined by counting the ends of the spirals near the cross walls.

Each chromatophore has from several to many disc-shaped pyrenoids spaced at regular intervals, and in certain species interrupting the median ridge. The margins of the chromatophores may be nearly smooth, or variously crenulate. Just after cell division the spiral pattern is continuous from one cell to the next, interrupted only by the thin partition wall. Chromatophores are examples of direct cytoplasmic inheritance. Through aplanospores they are derived directly from the chromatophores of the sporogenous cells. Through zygospores they are derived from the chromatophores of the *receptive* gametangia.

The cells of a filament are enclosed in a pectic sheath 1μ to 17μ

in thickness, and each cell may have an additional thin pectose wall and an inner cellulose wall next the protoplast. The transverse or end walls of the cells at maturity are of 4 types: plane, replicate, semireplicate, and colligate. These are probably fundamental cell differences. The first three types have long been used to separate three primary groups within the genus.

Following cell division the primary wall, or middle lamella of the partition wall, is composed of a pectic compound and has a plane surface. The secondary wall of cellulose also is plane in 208 species. In 65 species the cellulose layer develops a circular cuplike infold. (Pl. XXXV, Figs. 5–20.) Two other species have only a semicircular infold. (Pl. XXXV, Figs. 1–4.) In the adjacent cell the infold is opposite the plane half so that when these partition walls are seen from the side, the two folds resemble a partly open transom.

Not infrequently, in the division just preceding the formation of gametangia, the walls are plane even in the replicate species. There is 1 species *(S. colligata)* in which the middle lamella continues to grow in thickness and spread out over the ends of the cylindric wall. This process results in a collared diaphragm between successive cells. (Pl. XXXI, Figs. 11–13.) Isolated examples of collared diaphragms may be found in other species.

When cells with plane walls separate, the free ends become rounded. Free end walls of replicate species have a narrow central bulge with a distinct shoulder. The free ends of semireplicate cells have an asymmetric pointed bulge on the half where the infold occurred. As cells age, the transverse walls may become thickened and distorted through pectinization.

The replicate walls are curious structures. Since they first were seen, botanists have exercised their ingenuity to devise some important use or advantage for them. Frequently they have been held up as special adaptations for fragmentation. Yet all these botanists know that plane-walled filaments fragment without difficulty. When fragmentation occurs throughout a filament, the protoplasts are on their way to disintegration, not to multiplication.

The nucleus of a vegetative cell is located near its center, enclosed in cytoplasm supported by cytoplasmic strands, the outer ends of which usually adjoin a pyrenoid.

The simplest method of propagation and survival over a dormant period is by akinetes. These may be cylindric thick-walled

cells, or the thickening may be unequally distributed and modify the usual cell form. (Pl. I, Fig. 1.) Aplanospores are formed by the contraction of the contents of vegetative cells and the growth of a new and distinctive spore wall.

The "spore wall" is really a complex of three to five walls, one or more of which may be variously sculptured or ornamented. The outer wall is of cellulose and is usually colorless and transparent. Sometimes the outer wall is made up of two colorless layers, either of which may be thick and sculptured. The median spore wall at maturity is distinguished by its yellow to chestnut brown color resulting from chitinous deposits in or on the cellulose. This is the spore wall most frequently sculptured and ornamented. In some species the median wall also consists of two distinct chitinous layers. The inner spore wall is a thin cellulose layer lining the median wall and seldom seen, except when the spores are crushed. The median and the outer walls have a suture, more or less distinct, encircling the spore. At the time of germination these walls split along this line, while the inner wall enlarges with the protoplast and becomes the wall of the one celled sporeling. The walls of zygospores are similar to those of aplanospores.

The forms of *Spirogyra* spores are of three general types: *ellipsoid* (like an American football), *ovoid* (like a watermelon), and *lenticular* (a compressed spheroid). These forms may be slightly modified by elongation or compression but the curvatures of the polar ends remain the same. Usually there is no difficulty in recognizing the spore form of the 155 species with ellipsoid spores, and the 77 species with ovoid spores. There are 13 species, however, in which there is greater variation, and the form may be on either side of the border line between ovoid and ellipsoid. These are usually cared for in the keys by listing under both types. Compressed-ellipsoid, and compressed-ovoid spores are rare but do occur. The deviation of "lenticular" spores (30 species) from the form of a sphere may be as slight as an orange, or as great as a pocket watch. Obviously such spores are nearly circular in face view, and ovoid in side view.

Conjugating tubes are usually formed by both gametangia (228 species) but in 31 species they are outgrowths of the male gametangia. In a few species in which the receptive gametangia become greatly distended the part of the tubes formed by them

may be widened and nearly disappear, leaving the tubes "apparently formed by the male gametangia."

Another matter that must be determined early in the use of the key concerns the growth of the female, or receptive, gametangia during conjugation. Do they remain *cylindric,* or become slightly *enlarged,* or greatly distended or *inflated?* The two latter conditions we judge by the enlargement relative to the thickness of the spore. If the spore just fits the distended part of the gametangium it is *enlarged.* If gametangial walls are much more distended than the diameter of the spore, the gametangium is *inflated.* The inflation may be only on the conjugating, or inner, side, or it may be only on the opposite, or outer, side. In many species the inflation is on both sides.

The gametangial walls are not distended by the spore walls. Contrariwise the spore dimensions and forms are often limited by the gametangial walls. One can find many examples to prove this where spores formed in small gametangia are variously deformed by the rigidity of the gametangial wall.

Another interesting fact is that there is no proportional relation between the combined volumes of the gametangia and the volumes of the spores *in different species.* Spore sizes *in the same species,* however, are usually larger or smaller depending upon whether the volumes of the gametangia are larger or smaller than the average.

It is noteworthy that small spores in large gametangia are not free to move about as the cell is turned. The spores in all the Zygnemataceae are more or less fixed in position by an extremely dilute pectic gel that fills the entire cavity of the "empty" gametangia and sporangia. If these spaces were filled with water alone the position of the spores could be changed readily.

The last essential feature of the description of a *Spirogyra* is the number of spore walls, the color, and surface markings of each. The kinds of ornamentation are best shown by illustrations. Not all drawings are equally satisfactory, but some of the most difficult have been sketched with remarkable accuracy.

Spore wall features should be seen through an oil immersion lens, so that one can be sure to distinguish between the shadows of spore contents and actual wall structures. In drawing spores the contents should be omitted, since they are of no taxonomic value, while the wall characteristics have great importance.

Spore form, spore size, and wall ornamentation in hybrid zygospores are produced by the cytoplasm of the receptive gamete. For example, in collections containing filaments of two species interconjugating, the spore is always similar in form and approximate size to that of the specific filament in which the spore is formed. Hybridization between a species with plane-walled spores and a species with ornamented spore walls results in plane-walled or ornamented zygospores, depending upon the specific filament in which the receptive gamete is located. These facts fit in with observations on the movements of gametes during conjugation in which the male gamete moves into and through the cytoplasm of the female gamete and becomes enclosed by it. Thus the surface of the female gamete alone underlies the spore wall during its development. This is not interpreted as cytoplasmic inheritance. More probably the factors for these qualities of the cytoplasm are in the chromosomes. The cytoplasm is merely the mechanism by which spore wall forms, sizes, and patterns are formed.

The processes of gamete organization, movement, and union usually occur during the night. To study the successive steps through the microscope one must avoid subjecting the cells to intense light and high temperatures during the observations. Under these conditions the motile gametes may stop moving and become lodged at the sides or ends of the receptive gametes. This abnormal condition may be seen in published photographs of the process. Observations are best made at short intervals by turning the light on and off or by tilting the mirror backward and forward.

Analysis of Characteristics of the 275 Species of Spirogyra Here Described

Number of species with end walls plane is 208; semireplicate, 2; replicate, 65.

Extreme diameters of vegetative cells with end walls plane are 10–200 μ; semireplicate, 12–18 μ; replicate, 8–61 μ.

Number of chromatophores in species with end walls plane is 1 to 16; semireplicate, 1; replicate, 1 to 4.

Number of species usually having 1 chromatophore is 129; approximately 2 to 5 chromatophores, 109; and 6 to 16 chromatophores, 37.

Of the 208 species with *plane end walls*, the usual mode of conjugation is scalariform in 166, scalariform and lateral in 26, and lateral in 10. Conjugation is very rare or unknown in 6.

Of the 2 species with *semireplicate end walls,* conjugation is scalariform in 1, and unknown in the other.

Of the 65 species with replicate end walls, the usual mode of conjugation is scalariform in 33, scalariform and lateral in 25, and lateral in 6. Conjugation is unknown in 1 species.

Reproduction by zygospores alone occurs in 242 species; by both aplanospores and zygospores in 25 species; and by aplanospores alone in 8 species.

Conjugating tubes are formed by both gametangia among plane-walled species in 182; among semireplicate species in 1; and among replicate-walled species in 55.

Conjugating tubes are formed by the male gametangia in 25 plane-walled species, and in 12 replicate species. In several other species with inflated receptive gametangia, they appear to be formed by the male gametangia when seen in mature condition only.

A majority of the species with male conjugating tubes have short reproductive cells and longer vegetative cells alternating singly or in pairs in the filaments. The reproductive cells (pro-gametangia) can be distinguished readily before conjugation by their dark green color and dense cell contents. The vegetative cells have thin light green chromatophores and very transparent cytoplasm. Similar cell differences also characterize species of *Temnogametum* and *Sirogonium.* In all these species there is an evident transfer of food substances from the vegetative to the reproductive cells, before the initiation of conjugation or spore formation.

Spores are basically *ellipsoid* in 155 species; ovoid in 77; varying from ellipsoid to ovoid in 13; and more or less compressed-globose to lenticular in 30.

Of the 25 species known to produce both zygospores and aplanospores, 7 occur among the plane-walled species, and 18 among the replicate species.

Key to the Species of SPIROGYRA

1. Reproduction by zygospores 2
1. Reproduction by aplanospores (zygospores unknown or rare) 183
    2. End walls of cells all *plane* 3
    2. End walls of cells distinctly and uniformly *colligate* .... 157. *S. colligata*
    2. End walls of cells *semireplicate* 132
    2. End walls of cells *replicate* (in fruiting filaments many plane) 134

END WALLS PLANE

USUALLY ONE CHROMATOPHORE

3. Tubes evidently formed by projections from both gametangia 4
3. Tubes formed wholly, or almost wholly, by the male gametangia 117
   4. Vegetative cells with 1 chromatophore (rarely in some cells 2) 5
   4. Vegetative cells usually with more than 1 chromatophore (1–) 2–16 46
5. Median spore wall smooth (outer walls scrobiculate in Nos. 11, 40, and 41) 6
5. Median spore wall punctate, scrobiculate, reticulate, or verrucose 35
   6. Spores rather uniform (in optical section may appear variable because seen at different angles in different cells) 7
   6. Spores distinctly polymorphic when seen from the same angle (ellipsoid, ovoid, globose, and irregular) 33
7. Spores ellipsoid 9
7. Spores ovoid to cylindric-ovoid 24
7. Spores globose or compressed-globose 8
   8. Spores compressed-globose, diameter 55–65μ .... 152. *S. discoidea*
   8. Spores globose, or compressed-globose, diameter 85–95μ .... 153. *S. sphaerospora*

ONE CHROMATOPHORE

SPORES USUALLY ELLIPSOID, MEDIAN WALL SMOOTH

9. Sporangia cylindric, or enlarged 10
9. Sporangia inflated on both sides (larger than the spores) ... 19
9. Sporangia inflated mostly or only, on the conjugative side .. 14
9. Sporangia inflated mostly or only, on the outer side 23
   10. Diameter vegetative cells less than 40μ 11
   10. Diameter vegetative cells more than 40μ, spore diameter 34–38μ 6. *S. condensata*
   10. Diameter vegetative cells more than 40μ, spore diameter 42μ or more .... 7. *S. variformis*
   10. Diameter vegetative cells more than 60μ, spore diameter 60–66μ 33. *S. gallica*

11. Most of the spores less than 28 μ in thickness.............. 12
11. Most of the spores more than 28 μ in thickness............ 13

12. Diameter vegetative cells 11–14.5 μ, sterile cells inflated or bullate .... 50. *S. porangabae*
12. Diameter vegetative cells 19–22 μ, sterile cells bullate.............. 21. *S. bullata*
12. Diameter vegetative cells 18–26 μ 1. *S. communis*
12. Diameter vegetative cells 25–29 μ 2. *S. intorta*

13. Diameter vegetative cells 24–30 μ, diameter zygospores 28–33 μ........... 3. *S. juergensii*
13. Diameter vegetative cells 29–39 μ, diameter zygospores 27–36 μ........... 4. *S. singularis*
13. Diameter vegetative cells 32–40 μ, diameter zygospores 36–43 μ........... 5. *S. silvicola*

14. Vegetative cells less than 30 μ in diameter............. 15
14. Vegetative cells 30–40 μ in diameter.................. 17
14. Vegetative cells more than 40 μ in diameter........... 18

15. Diameter vegetative cells 19–21 μ..... 18. *S. gibberosa*
15. Diameter vegetative cells 16–24 μ..... 8. *S. gracilis*
15. Diameter vegetative cells 23–30 μ........................ 16

16. Fertile cells only slightly inflated 9. *S. fragilis*
16. Fertile cells strongly inflated.... 10. *S. teodoresci*

17. Median spore wall smooth, outer scrobiculate .... 11. *S. pseudovarians*
17. Median spore wall smooth, outer smooth .... 12. *S. varians*
17. Median spore wall smooth, with dark brown polar caps.................... 13. *S. bicalyptrata*

18. Diameter vegetative cells 40–50 μ, diameter spores 40–50 μ......... 14. *S. circumlineata*
18. Diameter vegetative cells 50–57 μ, diameter spores 35–40 μ......... 15. *S. supervarians*

19. Vegetative cells less than 24 μ in diameter.................. 20
19. Vegetative cells more than 24 μ in diameter................ 21

20. Chromatophore 1, diameter vegetative cells 15–19 μ, spore length 45–55 μ .... 16. *S. fennica*
20. Chromatophore 1–2, diameter vegetative cells 17–20 μ, sterile cells bullate .... 22. *S. pratensis*

20. Chromatophore 1, diameter vegetative cells 20–24 μ, spore length 48–60 μ	17. *S. parvula*
20. Chromatophore 1, diameter vegetative cells 20–25 μ, spore length 52–72 μ	268. *S. macrospora*
21. Fertile cells short, globose, spores 28–33 μ x 30–50 μ	23. *S. affinis*
21. Fertile cells longer, fusiform-inflated	22
22. Spore diameter 20–30 μ, yellow-brown	27. *S. subsalsa*
22. Spore diameter 22–29 μ, yellow	9. *S. fragilis*
22. Spore diameter 27–33 μ, yellow	24. *S. catenaeformis*
22. Spore diameter 28–38 μ, brown	25. *S. subsalina*
23. Diameter vegetative cells 30–35 μ	19. *S. borgeana*
23. Diameter vegetative cells 37–42 μ	20. *S. calcarea*

ONE CHROMATOPHORE

SPORES USUALLY OVOID, MEDIAN WALL SMOOTH

24. Vegetative cells usually less than 40 μ in diameter	25
24. Vegetative cells usually more than 40 μ in diameter	31
25. Diameter vegetative cells less than 15 μ	26. *S. flavescens*
25. Diameter vegetative cells more than 15 μ	26
26. Spore diameter usually less than 30 μ	27
26. Spore diameter usually more than 30 μ	28
27. Spores ovoid, diameter 18–20 μ	27. *S. subsalsa*
27. Spores ovoid, diameter about 24 μ	28. *S. paludosa*
27. Spores ovoid-ellipsoid, diameter 24–29 μ (usually aplanospores)	29. *S. mirabilis*
28. Fertile cells cylindric or enlarged	29
28. Fertile cells inflated on one or on both sides	30
29. Diameter zygospores 28–38 μ, yellow	30. *S. longata*
29. Diameter zygospores 33–38 μ, brown	269. *S. indica*
29. Diameter zygospores 36–43 μ, yellow-brown	5. *S. silvicola*
29. Diameter zygospores 37–57 μ, outer wall of 2 layers	40. *S. velata*
30. Fertile cells inflated on both sides	32. *S. suecica*
30. Fertile cells slightly inflated, second outer wall scrobiculate	40. *S. velata*
30. Fertile cells inflated on the inner side	12. *S. varians*

31. Diameter vegetative cells more than 60 μ .... 33. *S. gallica*
31. Diameter vegetative cells less than 60 μ 32
 32. Diameter vegetative cells usually 40–50 μ, median spore wall yellow 35. *S. porticalis*
 32. Diameter vegetative cells 38–44 μ, median spore wall yellow-brown 34. *S. lacustris*
 32. Diameter vegetative cells 43–50 μ, median spore wall brown....... 7. *S. variformis*
 32. Diameter vegetative cells 48–60 μ, median spore wall [?] "bluish-green" .... 36. *S. sahnii*

ONE CHROMATOPHORE

SPORES POLYMORPHIC, MEDIAN WALL SMOOTH

33. Vegetative cell diameter 17–21 μ, chromatophore 1–2, spores variable....... 22. *S. pratensis*
33. Vegetative cell diameter 22–40 μ, chromatophore 1......... 34
 34. Diameter vegetative cells 27–40 μ, spores variable in form......... 37. *S. lutetiana*
 34. Diameter vegetative cells 22–30 μ, spores variable in form......... 39. *S. polymorpha*

ONE CHROMATOPHORE

SPORES WITH MEDIAN WALL NOT SMOOTH

35. Spores ellipsoid 37
35. Spores ovoid 36
35. Spores globose .... 270. *S. czurdae*
 36. Median spore wall scrobiculate.. 42. *S. luteospora*
 36. Median spore wall reticulate.... 43. *S. sulcata*
 36. Median spore wall finely wrinkled .... 44. *S. westii*
 36. Median spore wall punctate..... 45. *S. obovata*
 36. Median spore wall granulate.... 46. *S. asiatica*
 36. Median spore wall of 2 layers... 263. *S. chekiangensis*
37. Vegetative cells usually less than 33 μ in diameter.......... 38
37. Vegetative cells 33–45 μ in diameter........................ 42
37. Vegetative cells more than 45 μ in diameter............... 45
 38. Fertile cells cylindric or enlarged..................... 39
 38. Fertile cells inflated on both sides.................... 40
 38. Fertile cells inflated on the inner side................. 41

39. Diameter vegetative cells 25–33 μ, fertile and sterile cells cylindric........ 47. *S. lagerheimii*
39. Diameter vegetative cells 18–25 μ, sterile cells bulliform.................. 48. *S. taftiana*
39. Diameter vegetative cells 14–18 μ, sterile cells not inflated................ 49. *S. perforans*
39. Diameter vegetative cells 11–14 μ, sterile cells inflated or bulliform......... 50. *S. porangabae*
 40. Diameter vegetative cells 11–14 μ, fertile cells slightly inflated...... 50. *S. porangabae*
 40. Diameter vegetative cells 16–19 μ, median spore wall grooved...... 51. *S. minutifossa*
 40. Diameter vegetative cells 14–17 μ, median spore wall reticulate.... 52. *S. skujae*
 40. Diameter vegetative cells 18–25 μ, median spore wall punctate..... 48. *S. taftiana*
 40. Diameter vegetative cells 26–29 μ, median spore wall punctate..... 53. *S. hoehnei*
 40. Diameter vegetative cells 29–35 μ, median spore wall coarsely punctate .... 54. *S. robusta*
41. Diameter vegetative cells 12–16 μ..... 179. *S. taylorii*
41. Diameter vegetative cells 22–26 μ..... 55. *S. subpapulata*
41. Diameter vegetative cells 28–32 μ..... 56. *S. papulata*
41. Diameter vegetative cells 30–40 μ..... 57. *S. scrobiculata*
41. Diameter vegetative cells about 17 μ.. 271. *S. sibirica*
 42. Fertile cells inflated mostly on the conjugative side.... 43
 42. Fertile cells enlarged or inflated on both sides......... 44
43. Diameter vegetative cells 32–38 μ, median spore wall punctate............ 58. *S. aphanosculpta*
43. Diameter vegetative cells 30–40 μ, median spore wall coarsely scrobiculate. 57. *S. scrobiculata*
43. Diameter vegetative cells 39–45 μ..... 59. *S. kaffirita*
 44. Median spore wall verrucose.... 60. *S. tuberculata*
 44. Median spore wall irregularly corrugate .... 61. *S. daedalea*
 44. Median spore wall irregularly reticulate .... 62. *S. daedaleoides*
45. Spores with median wall finely verrucose .... 63. *S. australensis*
45. Spores with median wall reticulate.. 64. *S. labyrinthica*
45. Spores with median wall finely granulate .... 272. *S. atasiana*

END WALLS PLANE

(ONE–) TWO TO SIXTEEN CHROMATOPHORES

46. Spores globose, ovoid, or ellipsoid, *not* laterally compressed 47
46. Spores globose, ovoid, or ellipsoid, *laterally* compressed 105
47. Median spore wall smooth.......... 48
47. Median spore wall not smooth.......... 75

SPORES NOT LATERALLY COMPRESSED

MEDIAN WALL SMOOTH

48. Vegetative cells with less than 9 chromatophores...... 49
48. Vegetative cells with more than 9 chromatophores.... 71
49. Fertile cells cylindric, or enlarged.......... 50
49. Fertile cells inflated.......... 72
50. Spores ellipsoid or cylindric-ellipsoid.......... 51
50. Spores ovoid or cylindric-ovoid, rarely globose........ 62
51. Vegetative cells usually less than 45 μ in diameter.......... 52
51. Vegetative cells usually 45–60 μ in diameter.......... 54
51. Vegetative cells more than 60 μ in diameter.......... 56
52. Chromatophores 2 to 3 in each cell.......... 53
52. Chromatophores 2 to 4, diameter vegetative cells 32–37 μ...... 66. *S. irregularis*
52. Chromatophores 3 in each cell.. 67. *S. fuellebornei*
52. Chromatophores 2 in each cell, spores 29–32 μ x 51–61 μ......... 68. *S. microspora*
52. Chromatophores 2 in each cell, spores 38–42 μ x 60–78 μ......... 69. *S. hollandiae*
53. Diameter vegetative cells 21–32 μ..... 70. *S. submarina*
53. Diameter vegetative cells 36–41 μ..... 71. *S. rivularis*
53. Diameter vegetative cells 38–48 μ..... 72. *S. biformis*
54. Chromatophores, 3, 1–3, or 2–3.......... 55
54. Chromatophores 2–4 .... 73. *S. hyalina*
55. Chromatophores 3, diameter vegetative cells 55–60 μ.......... 74. *S. pseudoneglecta*
55. Chromatophores (1–)3, diameter vegetative cells 48–54 μ.......... 75. *S. columbiana*
55. Chromatophores 2 to 3, diameter vegetative cells 49–62 μ.......... 76. *S. angolensis*
56. Diameter vegetative cells between 60 and 80 μ......... 57
56. Diameter vegetative cells between 80 and 120 μ........ 60
56. Diameter vegetative cells more than 120 μ.......... 61

57. Spore diameters less than 60 μ 58
57. Spore diameters greater than 60 μ 59
58. Chromatophores 2 to 3, spores 57–58 μ x 69–71 μ .... 77. *S. welwitschii*
58. Chromatophores 4, spores about 50 μ x 75–100 μ .... 78. *S. parvispora*
59. Chromatophores 3 to 4, spores 63–68 μ x 120–140 μ .... 79. *S. turfosa*
59. Chromatophores (2–3)4, spores 57–68 μ x 100–210 μ .... 98. *S. szechwanensis*
59. Chromatophores 3 to 5, spores 60–80 μ x 90–170 μ .... 80. *S. nitida*
60. Chromatophores (2–)3(–4), diameter vegetative cells 86–92 μ .... 81. *S. hymerae*
60. Chromatophores 4, diameter vegetative cells 90–115 μ .... 82. *S. setiformis*
60. Chromatophores 4–6, diameter vegetative cells 115–128 μ .... 83. *S. elliptica*
60. Chromatophores 6–8, diameter vegetative cells 90–100 μ .... 84. *S. wollnyi*
60. Chromatophores 6–8, diameter vegetative cells 98–110 μ .... 86. *S. yunnanensis*
61. Diameter vegetative cells 115–128 μ, chromatophores 6–8 .... 87. *S. hatillensis*
61. Diameter vegetative cells 125–150 μ, chromatophores 3 to 8 .... 88. *S. ellipsospora*
61. Diameter vegetative cells 158–166 μ, chromatophores 5 to 6 .... 89. *S. splendida*
62. Vegetative cells less than 60 μ in diameter 63
62. Vegetative cells more than 60 μ in diameter 68
63. Chromatophores 3 or less in each cell 64
63. Chromatophores 4 to 5, diameter vegetative cells 50–60 μ .... 90. *S. emilianensis*
64. Vegetative cells with 2 chromatophores 65
64. Vegetative cells with 3 chromatophores 66
64. Vegetative cells with 2 or 3 chromatophores (rarely 1 in No. 41) 67
65. Diameter vegetative cells 27–30 μ, sterile cells inflated to 50 μ .... 91. *S. exilis*
65. Diameter vegetative cells 48–52 μ, sterile cells inflated to 75 μ .... 92. *S. distenta*

66. Spores 34–48 μ x 48–54 μ .... 93. *S. triplicata*
66. Spores 46–50 μ x 81–124 μ .... 94. *S. siamensis*
66. Spores 54–64 μ x 75–100 μ .... 95. *S. neglecta*

67. Diameter vegetative cells 32–42 μ, spores 31–40 μ (outer wall single) .... 96. *S. decimina*
67. Diameter vegetative cells 38–44 μ, spores 40–44 μ (outer wall single) .... 97. *S. plena*
67. Diameter vegetative cells 40–50 μ (second outer spore wall hyaline, scrobiculate) .... 41. *S. occidentalis*

68. Vegetative cells usually less than 75 μ in diameter 69
68. Vegetative cells usually more than 75 μ in diameter 70

69. Chromatophores 3, diameter vegetative cells 55–67 μ .... 95. *S. neglecta*
69. Chromatophores 3–4, diameter vegetative cells 60–78 μ (spore usually ellipsoid) .... 80. *S. nitida*

70. Diameter spores 57–68 μ, chromatophores 4–(3–2) .... 98. *S. szechwanensis*
70. Diameter spores 87–108 μ, chromatophores 3 to 4 .... 99. *S. jugalis*

71. Vegetative cell diameter 100–120 μ, chromatophores 13–15 .... 100. *S. margaritata*
71. Vegetative cell diameter 150–189 μ, chromatophores 12–14 .... 101. *S. polytaeniata*

72. In each cell 2 chromatophores 73
72. In each cell 2 or 3 chromatophores 74
72. In each cell 4 to 6 chromatophores 102. *S. jaoensis*

73. Zygospores ellipsoid, diameter vegetative cells 20–24 μ .... 103. *S. baileyi*
73. Zygospores ellipsoid, diameter vegetative cells 44–48 μ .... 104. *S. buchetii*
73. Zygospores ellipsoid, diameter vegetative cells 60–75 μ .... 105. *S. bichromatophora*

74. Diameter vegetative cells 26–28 μ, chromatophores 2 to 3 .... 106. *S. rhizoides*
74. Diameter vegetative cells 40–50 μ, chromatophores 2 to 3 .... 107. *S. dubia*
74. Diameter vegetative cells 55–67 μ, chromatophores 3 .... 95. *S. neglecta*

SPORES NOT LATERALLY COMPRESSED

MEDIAN WALL NOT SMOOTH

75. Diameter vegetative cells between 16μ and 25μ............ 76
75. Diameter vegetative cells mostly between 25μ and 35μ..... 77
75. Diameter vegetative cells between 35μ and 60μ............ 84
75. Diameter vegetative cells between 60μ and 125μ.......... 96

76. Spores ellipsoid, chromatophores 3, diameter vegetative cells 22–26μ .... 117. *S. chungkingensis*
76. Spores ovoid, chromatophores 2–1, diameter vegetative cells 16–22μ .... 108. *S. puncticulata*
76. Spores ellipsoid, chromatophores 3–2, diameter vegetative cells 20–25μ .... 115. *S. miamiana*
76. Spores ovoid, chromatophores 3–2, diameter vegetative cells 23–25μ .... 109. *S. aequinoctialis*

77. Zygospores ovoid 78
77. Zygospores ellipsoid 79

78. Chromatophores 2, diameter vegetative cells 25–32μ............. 110. *S. rhizopus*
78. Chromatophores 3–2, diameter vegetative cells 28–32μ .... 111. *S. dictyospora*
78. Chromatophores 2–4, diameter vegetative cells 30–37μ, median spore wall double.............. 135. *S. notabilis*
78. Chromatophores 1–3, diameter vegetative cells 31–36μ.......... 112. *S. natchita*
78. Chromatophores 3–4, diameter vegetative cells 30–45μ.......... 133. *S. fluviatilis*

79. Diameter spores usually less than 32μ, 2 chromatophores .... 113. *S. fossa*
79. Diameter spores between 32 and 43μ...................... 80
79. Diameter spores usually more than 43μ................... 81

80. Median spore wall punctate or scrobiculate........... 82
80. Median spore wall reticulate........................ 83

81. Chromatophores 2–3(–4), diameter spores 43–46μ .... 114. *S. schmidtii*
81. Chromatophores 3–4, diameter spores 45–52μ .... 116. *S. smithii*

82. Median spore wall double, outer wrinkled, inner punctate........ 117. *S. chunkingensis*
82. Median spore wall single, finely scrobiculate .... 118. *S. orientalis*

83. Chromatophores 2, spores very irregularly reticulate .... 110. *S. rhizopus*
83. Chromatophores 2–4, regularly reticulate .... 119. *S. subcylindrospora*

84. Zygospores ellipsoid 85
84. Zygospores ovoid 92

85. Chromatophores 2–3, diameter vegetative cells 34–37 μ.................. 120. *S. castanacea*
85. Chromatophores 2–3, diameter vegetative cells 42–48 μ.................. 121. *S. mienningensis*
85. Chromatophores 3, diameter vegetative cells 46–52 μ.................... 122. *S. shantungensis*
85. Chromatophores 3, diameter vegetative cells 50–60 μ.................... 123. *S. braziliensis*
85. Chromatophores 3–5 86

86. Diameter vegetative cells mostly less than 55 μ......... 87
86. Diameter vegetative cells mostly more than 55 μ....... 90

87. Spore diameter mostly less than 54 μ....................... 88
87. Spore diameter 48–64 μ, 4–3(–2) chromatophores .... 124. *S. pulchrifigurata*
87. Spore diameter 67–72 μ, 3–5 chromatophores .... 125. *S. torta*

88. Median spore wall of a single layer................... 89
88. Median spore wall double, outer wrinkled, inner punctate....... 126. *S. quadrilaminata*
88. Median spore wall double, outer wrinkled, inner smooth......... 129. *S. subreticulata*

89. Median spore wall finely, irregularly reticulate, spore 38–60 μ x 64–100 μ... 127. *S. rhizobrachialis*
89. Median spore wall irregularly corrugate, spores 37–41 μ x 48–65 μ...... 128. *S. paraguayensis*

90. Fertile cells cylindric or enlarged 130. *S. minor*
90. Fertile cells inflated.................................. 91

91. Median spore wall intricately reticulate .... 131. *S. brunnea*
91. Median spore wall angularly punctate 132. *S. scripta*

92. Fertile cells inflated.................................. 93

92. Fertile cells cylindric or enlarged 95
93. Chromatophores 3 in each cell 94
93. Chromatophores 3–4, diameter vegetative cells 35–45 μ .... 133. *S. fluviatilis*
93. Chromatophores 3–4, diameter vegetative cells 50–60 μ .... 134. *S. africana*
94. Median spore wall irregularly corrugate .... 136. *S. grossii*
94. Median spore wall granulose .... 137. *S. ovigera*
95. Median spore wall reticulate, brown, diameter spore 42–54 μ .... 129. *S. subreticulata*
95. Median spore wall scrobiculate, yellow, diameter spore 50–65 μ .... 138. *S. novae-angliae*
96. Zygospores ellipsoid 97
96. Zygospores ovoid 101
97. Median spore wall verrucose 98
97. Median spore wall reticulate 99
97. Median spore wall pitted, scrobiculate, or punctate 100
98. Chromatophores 4–8, diameter spores 89–100 μ .... 274. *S. verrucosa*
98. Chromatophores 2–3, diameter spores 48–52 μ .... 120. *S. castanacea*
98. Chromatophores 2, diameter spores 54–60 μ .... 123. *S. braziliensis*
98. Chromatophores 5, diameter spores 105–120 μ .... 140. *S. verruculosa*
99. Diameter spores 55–66 μ, fertile cells inflated, chromatophores 3–5 .... 131. *S. brunnea*
99. Diameter spores 65–83 μ, fertile cells cylindric, chromatophores 3–4 .... 141. *S. malmeana*
99. Diameter spores 73–90 μ, fertile cells cylindric, chromatophores 5–10 ...... 139. *S. anomala*
100. Chromatophores 3, diameter spores 42–60 μ .... 142. *S. propria*
100. Chromatophores 4–6(–8), diameter spores 87–108 μ .... 143. *S. trachycarpa*
100. Chromatophores (3–)4–5(–7), diameter spores 64–74 μ .... 145. *S. punctulata*
101. Fertile cells cylindric, chromatophores 4 .... 146. *S. cylindrospora*
101. Fertile cells cylindric or enlarged, chromatophores 5 .... 140. *S. verruculosa*

101. Fertile cells cylindric, chromatophores 6–7 .... 144. *S. ghosei*
101. Fertile cells enlarged or inflated, chromatophores 3–8...... 102
 102. Diameter vegetative cells less than 85 μ................ 103
 102. Diameter vegetative cells more than 85 μ.............. 104
103. Vegetative cell diameter 54–60 μ, chromatophores 3–4 .... 134. *S. africana*
103. Vegetative cell diameter 56–71 μ, chromatophores 3–5 .... 131. *S. brunnea*
103. Vegetative cell diameter 66–72 μ, chromatophores 6–8 .... 147. *S. echinospora*
103. Vegetative cell diameter 70–85 μ, chromatophores 5–8 .... 148. *S. diluta*
 104. Median spore wall echinate, chromatophores 4–7 .... 149. *S. echinata*
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105. Spores compressed-ovoid.. 106
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 106. Median spore wall pitted.. 107
 106. Median spore wall verrucose, chromatophores 11–16 .... 176. *S. rectispira*
107. Diameter vegetative cells 80–95 μ, chromatophores 6–12 .... 164. *S. formosa*
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110. Vegetative cell diameter 32–36 μ, chromatophores 3–4 .... 155. *S. frankliniana*
110. Vegetative cell diameter 40–50 μ, chromatophores 3–4 .... 156. *S. pellucida*
110. Vegetative cell diameter 29–40 μ, chromatophores 4–6 .... 157. *S. colligata*
110. Vegetative cell diameter 40–45 μ, chromatophores 4–7 .... 267. *S. subpellucida*

111. Diameter vegetative cells 50–80 μ, chromatophores 3–8 .... 158. *S. majuscula*
111. Diameter vegetative cells 70–110 μ, chromatophores 8–9 .... 159. *S. submaxima*
111. Diameter vegetative cells 145–155 μ, chromatophores 7 .... 160. *S. glabra*
111. Diameter vegetative cells 113–125 μ, chromatophores 5–6 .... 265. *S. peipingensis*

112. Vegetative cell diameter 32–40 μ, median spore wall punctate..... 266. *S. sphaerocarpa*
112. Vegetative cell diameter 65–80 μ, median spore wall irregularly pitted .... 161. *S. bellis*
112. Vegetative cell diameter 80–118 μ..................... 113
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113. Chromatophores 9–13, median spore wall verrucose .... 163. *S. oblata*
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113. Chromatophores 7–10, median spore wall reticulate-verrucose .... 168. *S. manoramae*

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115. Diameter vegetative cells 118–140 μ, 6–7 chromatophores, median spore wall reticulate .... 170. *S. maxima*

115. Diameter vegetative cells 130–150 μ, about 8 chromatophores, median spore wall verrucose .... 171. *S. heeriana*
116. Diameter vegetative cells 150–170 μ, 6–7 chromatophores...... 172. *S. crassiuscula*
116. Diameter vegetative cells 170–200 μ, 6–7 chromatophores....... 173. *S. megaspora*
116. Diameter vegetative cells 150–162 μ, 9–10 chromatophores...... 174. *S. lenticularis*

CONJUGATING TUBES FORMED BY THE MALE GAMETANGIA; SHORT FERTILE CELLS OFTEN ALTERNATING SINGLY, OR IN PAIRS, WITH LONG STERILE CELLS

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120. Median spore wall coarsely punctate .... 181. *S. prescottii*
120. Median spore wall reticulate to punctate .... 179. *S. taylorii*
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121. Spores with median wall coarsely punctate .... 183. *S. collinsii*
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121. Spores with median wall reticulate... 186. *S. lushanensis*
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123. Median spore wall irregularly reticulate, diameter vegetative cells 27–33 μ 187. *S. esthonica*

124. Median spore wall punctate, diameter vegetative cells 27–30 μ... 189. *S. punctiformis*
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130. Chromatophores 3–5, median spore wall reticulate............ 178. *S. texensis*

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141. Zygospores 22–26(–32) μ x 51–103 μ.. 228. *S. arta*
141. Zygospores 30–36 μ x 55–110 μ, some fertile cells inflated................ 226. *S. spreeiana*
141. Zygospores 25–35 μ x 48–86 μ, sterile cells inflated .... 229. *S. tumida*
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142. Zygospores 30–33 μ x 60–82 μ, outer wall thin................. 232. S. *laxa*
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157. Median spore wall single, spores 23–30μ x 42–56μ................... 221. *S. goetzei*
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163. Diameter vegetative cells 16–19 μ..... 203. *S. pseudospreeiana*

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164. Zygospores 24–28 μ x 46–52 μ.... 227. *S. tsingtaoensis*

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165. Diameter vegetative cells 18–21 μ..... 204. *S. pascheriana*

166. Vegetative cell diameter 17–25 μ, spores ellipsoid .... 230. *S. croasdaleae*

166. Vegetative cell diameter 21–25 μ, spores ovoid .... 210. *S. grevilleana*

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 170. Chromatophores 2, diameter vegetative cells 29–32 μ............. 275. *S. marchica*
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 170. Chromatophores 2–3, diameter vegetative cells 37–40 μ.......... 245. *S. proavita*
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175. Chromatophores (1–)2, diameter zygospores 42–52 μ, median wall dotted. 212. *S. incrassata*
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REPLICATE END WALLS

TWO OR MORE CHROMATOPHORES, MEDIAN SPORE WALL NOT SMOOTH

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180. Chromatophores 3–4, reticulate-spinose .... 251. *S. acanthophora*
180. Chromatophores 2–4, spore diameter 52–62 μ, mammillate-aculeate 253. *S. borysthenica*
180. Chromatophores 2, spore diameter 42–50 μ, median wall double 264. *S. crassispina*
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181. Chromatophores (1–)2–3, diameter spore 45–60 μ, median wall double... 256. *S. reticulata*
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182. Spores, diameter 39–45 μ, median wall single, reticulate........... 257. *S. regularis*
182. Spores, diameter 45–55 μ, median wall double, inner granulate.... 259. *S. granulata*
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REPRODUCTION WHOLLY OR MOST COMMONLY BY APLANOSPORES

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183. End walls semireplicate, diameter vegetative cells 12–14 μ................. 198. *S. narcissiana*
183. End walls replicate, diameter vegetative cells 24–28 μ.................... 234. *S. articulata*
184. With 1 chromatophore................................ 185
184. With 2 or more chromatophores..................... 186
185. Sporangia cylindric, aplanospores ovoid .... 31. *S. oltmannsii*
185. Sporangia enlarged or slightly inflated 29. *S. mirabilis*
185. Sporangia and sterile cells often inflated .... 38. *S. aplanospora*
186. With 2 to 3 chromatophores in each cell, spores ellipsoid....... 65. *S. maravillosa*

186. With 6 to 8 chromatophores in each cell, spores ellipsoid....... 85. *S. wrightiana*
186. With 5 chromatophores in each cell, spores lenticular........... 166. *S. azygospora*

Aplanospores have been found together with zygospores in some collections of the following species: *S. catenaeformis*, *S. denticulata*, *S. farlowii*, *S. gratiana*, *S. groenlandica*, *S. hyalina*, *S. inflata*, *S. juergensii*, *S. majuscula*, *S. neglecta*, *S. obovata*, *S. parvula*, *S. pratensis*, *S. protecta*, *S. quadrata*, *S. quinquelaminata*, *S. reflexa*, *S. sahnii*, *S. semiornata*, *S. spreeiana*, *S. subpapulata*, *S. tenuissima*, *S. tjibodensis*, *S. varians*, *S. weberi*.

Descriptions of Species

SPECIES WITH PLANE END WALLS
USUALLY ONE CHROMATOPHORE

1. Spirogyra communis (Hassall) Kützing 1849. *Species Algarum*, p. 439. Hassall. 1844. *History of British Freshwater Algae*. p. 148, Pl. 28, Figs. 5–6.

Vegetative cells 18–26μ x 35–90μ with plane end walls; 1 chromatophore, making 1.5 to 4 turns; conjugation scalariform and lateral; tubes formed by both gametangia; fertile cells cylindric, rarely enlarged; zygospores ellipsoid, 19–26μ x 36–78μ; median spore wall yellow, smooth. (Pl. XXI, Fig. 1.)

United States: Colorado to Texas; east to Massachusetts and New Jersey.

Reported from all the continents, also New Caledonia.

Distinguished from other species with similar vegetative cells and with approximately the same dimensions by the smooth ellipsoid spores, the cylindric fertile cells, and the absence of inflated sterile cells. Found hybridizing with *S. varians* at Charleston, Illinois. The resulting segregates were also present.

2. Spirogyra intorta Jao 1935. *Sinensia*. 6, p. 590, Pl. 5, Fig. 58.

Vegetative cells 25–29μ x 60–183μ, with plane end walls; filaments generally curved to spiral; 1 chromatophore, making 3.5–6 turns in the cell; conjugation scalariform and lateral; tubes formed by both gametangia; fertile cells cylindric, sometimes slightly enlarged; zygospores ellipsoid, with pointed ends, 22–29μ x 41–68μ; median spore wall yellow, smooth. (Pl. XXI, Fig. 2.)

United States: Texas, Johnson City, April 24, 1938 (Taft Coll.).

China, Szechwan.

3. SPIROGYRA JUERGENSII Kützing 1845. *Phycologia Germanica,* p. 222.

Vegetative cells 24–30μ x 60–125μ, with plane end walls; 1 chromatophore, making 2 to 4 turns; conjugation scalariform and lateral; tubes formed by both gametangia; fertile cells cylindric or enlarged toward the middle (to 34μ); zygospores and aplanospores ellipsoid, 28–33μ x 50–75μ; median spore wall yellow, smooth. (Pl. I, Fig. 1; Pl. XXI, Fig. 3.)

United States: California; from Wisconsin, Iowa, and Texas to the east coast.

Widely distributed in Europe; South America; Australia.

Distinguished from *S. longata* by the ellipsoid spores. Sometimes at maturity the stretching of the fertile cell wall shortens that end of the conjugating tube, and the tube has the appearance of having been formed by the male cell as in *S. punctiformis* and *S. micropunctata.* From the former it is distinguished by the ellipsoid, smooth spores; from the latter by the smaller size and smooth spore wall. In a collection from Mississippi cylindrically inflated akinetes with thick walls were present together with zygospores. The dimensions of the akinetes varied from 48–60μ x 108–140μ. (Pl. I, Fig. 1.)

4. SPIROGYRA SINGULARIS Nordstedt 1880. *Bot. Notiser* 1880. p. 118. Wittrock and Nordstedt Algae Exsiccatae, No. 361.

Vegetative cells 29–39μ x 60–240μ, with plane end walls; 1 chromatophore, making 3 to 7 turns; conjugation scalariform; tubes formed by both gametangia, fertile cells cylindric, rarely enlarged; zygospores ellipsoid, 27–36μ x 46–70μ; median spore wall yellow, smooth. (Pl. XXI, Fig. 4.)

United States: Michigan and Texas, to the east coast.

Described from New Zealand; reported from Finland; South Africa; China; Brazil.

Distinguished from *S. longata* by the ellipsoid spores. In all specimens seen the chromatophores were narrow and the spirals very open.

5. SPIROGYRA SILVICOLA Britton 1943. *Amer. Jour. Bot.* **30**, p. 799, Fig. 1.

Vegetative cells 32–42μ x 63–267μ, with plane end walls; 1 chromatophore, making 1.5 to 3 turns in the cell; conjugation scalariform; tubes formed by both gametangia; receptive gametangia cylindric or slightly enlarged; zygospores ellipsoid to cylindric-ovoid, 36–43μ x 56–103μ; all walls smooth; median wall yellow or brown at maturity. (Pl. XXI, Fig. 7.)

United States: Illinois, Somme Forest, Cook County, May 15, 1938 (Britton Coll.); Texas, Austin (Taft Coll.).

Vegetative cells similar to those of *S. singularis*; zygospores much larger.

6. Spirogyra condensata (Vaucher) Kützing 1843. *Phycologia Generalis*, p. 279.

Vegetative cells 45–60 μ x 45–120 μ, with plane end walls; 1 chromatophore, making .5 to 4 turns; conjugation scalariform and lateral; tubes formed by both gametangia; fertile cells cylindric or slightly enlarged; zygospores ellipsoid, 34–38 μ x 50–75 μ; median spore wall yellow, smooth. (Pl. XXI, Fig. 11.)

United States: Wisconsin and Kentucky; eastward to Massachusetts and New Jersey.

Widely distributed in Europe; reported from South America.

Characterized by its short cells and closely spiraled chromatophores. Sterile cells sometimes inflated.

7. Spirogyra variformis Transeau 1938. *Amer. Jour. Bot.* 25, pp. 526–27.

Vegetative cells 43–50 μ x (70–)108–140(–200) μ with plane end walls; 1 chromatophore, making 2 to 5 turns in the cell; conjugation scalariform; tubes formed by both gametangia and widest at the middle; some sterile cells inflated to 72–100 μ; fertile cells mostly cylindric but sometimes enlarged or inflated; zygospores ellipsoid or ovoid, 45–54 μ x 58–90 μ, rarely spherical, 52–60 μ in diameter; median wall brown, smooth. (Pl. XXI, Figs. 9–10.)

Africa, Cape Town (Stephens Coll.).

8. Spirogyra gracilis (Hassall) Kützing 1849. *Species Algarum*, p. 438.

Vegetative cells 16–24 μ x 50–100 μ, with plane end walls; 1 chromatophore, making .5 to 4 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated, mostly on the conjugating side; zygospores ellipsoid with rounded ends, 23–30 μ x 40–65 μ; median spore wall yellow-brown, smooth. (Pl. XXI, Fig. 5.)

United States: Colorado; Texas; Missouri; Michigan; Ohio; Massachusetts.

Widely distributed in Europe; reported also from China and Siam.

9. Spirogyra fragilis Jao 1935. *Sinensia.* 6, p. 590, Pl. 6, Fig. 64.

Vegetative cells 24–29 μ x 54–160 μ, with plane end walls; chromatophore 1 (rarely 2), making 1.5–6 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells slightly inflated, usually a little more on the conjugating side; the female gametangia often separate from each other after conjugation; zygospores ellipsoid with more or less rounded ends, 22–38 μ x 36–67 μ; median spore wall yellow, smooth. (Pl. XXI, Fig. 6.)

United States: Texas, Johnson City, April 24, 1938 (Taft Coll.).

China, Szechwan.

The separation of the sporiferous cells is an unusual feature but also occurs frequently in *S. parvula.*

10. SPIROGYRA TEODORESCI Transeau 1934. *Ohio Jour. Sci.* **34**, p. 420. (=*S. varians* var. *minor*) Teodoresco. *Beih. Bot. Zentralbl.* **21**, abt. 2. 1907.

Vegetative cells 24–30μ x 42–90μ, with plane end walls; 1 chromatophore, making 1 to 6 turns; conjugation scalariform and lateral; tubes formed by both gametangia; fertile cells strongly inflated on the conjugating side; zygospores ellipsoid, 26–33μ x 45–55μ; median spore wall smooth, yellow. (Pl. XXI, Fig. 8.)

United States: Iowa; Illinois; Michigan; Kentucky; New York; Massachusetts.

Rumania; China, Nanking, Peiping (Li Coll.).

Probably included in many records of *S. varians,* from which it is distinguished by its smaller dimensions throughout.

11. SPIROGYRA PSEUDOVARIANS Czurda 1930. *Beih. Bot. Zentralbl.* **47**, p. 32.

Vegetative cells 36–39μ x 35–75μ, with plane end walls; chromatophores 1 (rarely 2); conjugation scalariform; tubes formed by both gametangia; fertile cells swollen, mostly on the conjugating side; zygospores ellipsoid, 33–37μ x 47–57μ; outer spore wall thick, transparent, scrobiculate; median spore wall reddish-brown, smooth; sterile cells more or less swollen. (Pl. XXI, Figs. 12–14.)

Czechoslovakia; Austria.

Distinguished by the heavy, transparent, shallow-scrobiculate *outer* wall.

12. SPIROGYRA VARIANS (Hassall) Kützing 1849. *Species Algarum,* p. 439. Includes *S. woodsii* Czurda and *S. varians* (Kützing) Czurda.

Vegetative cells (28–)30–40μ x 30–120μ, with plane end walls; 1 chromatophore, with 1 to 5 turns; conjugation scalariform and lateral; tubes formed by both gametangia; fertile cells usually inflated on the conjugating side only, rarely on both sides; some of the sterile cells usually inflated; zygospores mostly ellipsoid, usually some of them ovoid and very rarely globose, 32–40μ x 50–100μ; median spore wall yellow, smooth; aplanospores similar. (Pl. XXII, Fig. 1.)

Generally distributed in the United States, including Alaska.

Also reported from British Columbia to Newfoundland.

Widely distributed in Europe, Asia, Africa, and Australia.

A highly variable species, but usually readily identified by the combi-

nation of dimensions, unilaterally inflated sporiferous cells, and the inflated sterile cells. Has been found hybridizing with *S. porticalis, S. longata,* and *S. communis* and producing a variety of segregates. Due to the occurrence of haploid segregates and the wide overlapping of cell and spore dimensions, it has not been found advisable to separate the variants further.

13. Spirogyra bicalyptrata Czurda 1930. *Beih. Bot. Zentralbl.* 47, p. 31.

Vegetative cells 36–39μ x 60–110μ, with plane end walls; chromatophore 1 (rarely 2); conjugation scalariform; tubes formed by both gametangia; fertile cells swollen on the conjugating side; zygospores ellipsoid, 31–34μ x 55–70μ; median spore wall brown, smooth, with dark brown polar thickenings. (Pl. XXII, Fig. 2.)

Czechoslovakia; Austria; Greece.

Distinguished from *S. varians* by the occurrence of 2 chromatophores in some cells and the brown polar thickening of the median wall. A similar local polar thickening sometimes occurs in scattered spores of other species.

14. Spirogyra circumlineata Transeau 1914. *Amer. Jour. Bot.* 1, p. 293.

Vegetative cells (38–)40–48μ x 120–240μ, with plane end walls; 1 chromatophore, slender, making 4 to 8 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated on the conjugating side only; zygospores ellipsoid, 40–50μ x 70–125μ; median spore wall yellow-brown, smooth; suture more or less prominent. (Pl. XXII, Fig. 3.)

United States: Iowa; Illinois; Michigan; Ohio.

Distinguished from *S. varians* by the larger dimensions, the slender chromatophore making a larger number of turns, the distinct suture encircling the spore, and the absence of inflated sterile cells.

15. Spirogyra supervarians Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 208.

Vegetative cells 50–57μ x 50–144μ; 1 chromatophore; cells with plane end walls; conjugation scalariform; tubes formed by both gametangia; receptive gametangium inflated on the inner side; zygospores ellipsoid, small in proportion to the gametangia, 35–40μ x 54–74μ; median spore wall smooth, yellow. (Pl. XXII, Fig. 7.)

Africa, Cape Flats (E. Stephens Coll.).

Similar to *S. varians* in appearance, but with much larger dimensions throughout, and without inflated sterile cells.

16. Spirogyra fennica Cedercreutz 1924. *Acta Soc. pro Fauna et Flora Fennica.* 55 (2), p. 4.

Vegetative cells 15–19μ x 60–260μ, with plane end walls; 1 chro-

matophore; conjugation scalariform; tubes formed by both gametangia; fertile cells shortened and inflated to 34–39 μ; zygospores ellipsoid, 24–31 μ x 45–55 μ; median spore wall yellow-brown, smooth. (Pl. XXII, Fig. 4.)

Finland; China, Szechwan; South Africa.

Distinguished from *S. parvula* by the much smaller vegetative cells; and from *S. pratensis* by the absence of cells with 2 chromatophores, and by the absence of globosely inflated sterile cells.

17. SPIROGYRA PARVULA (Transeau) Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 170, Fig. 174.

Vegetative cells 20–24 μ x 50–105 μ, with plane end walls; 1 chromatophore, making 1 to 6 turns; conjugation mostly lateral, sometimes scalariform; tubes formed by both gametangia; fertile cells inflated up to 37 μ, often separating from one another but held in place by the male filament; zygospores ellipsoid, 20–27 μ x 40–60 μ; median spore wall yellow-brown, smooth; aplanospores similar in size and shape to zygospores. (Pl. XXII, Figs. 5–6.)

United States: Iowa and Texas, to New York.

Norway; India; China.

18. SPIROGYRA GIBBEROSA Jao 1935. *Sinensia.* 6, p. 586, Pl. 4, Figs. 50–51.

Vegetative cells 19–21 μ x 48–104 μ, with plane end wall; 1 chromatophore, making 2 to 8 turns in the cell; conjugation scalariform, sometimes lateral; tubes formed by the male gametangia; fertile cells inflated on the conjugating side, to 45 μ, often separating from each other as the spores mature; zygospores ellipsoid with more or less pointed ends, 22–29 μ x 38–50 μ; median spore wall smooth, yellow at maturity. (Pl. XXII, Figs. 10–11.)

China, Szechwan.

Separation of the sporiferous cells after conjugation is similar to that frequently seen in *S. parvula*. Placed here because of doubt that tubes are formed by the male gametangia. This may be only apparent, because of subsequent enlargement of the receptive gametangia.

19. SPIROGYRA BORGEANA Transeau 1915. *Ohio Jour. Sci.* 16, p. 23.

Vegetative cells 30–35 μ x 50–200 μ; with plane end walls; 1 chromatophore, making 1.5 to 5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated on the outer side, cylindric on the conjugating side; zygospores ellipsoid, 30–40 μ x 54–70 μ; median spore wall yellow, smooth. (Pl. XXII, Fig. 8; Pl. XXIII, Fig. 16.)

United States: Iowa; Illinois; Michigan; Indiana; Ohio.

Czechoslovakia; Tibet; China.

Figure 16 on Plate XXIII depicts an instance in which the terminal cells of 2 adjacent filaments conjugated through the end walls with 2 adjoining receptive gametangia of a third filament. The specimen was collected near Douglas Lake, Michigan. Named for the late Oskar F. A. Borge of Stockholm, Sweden.

20. Spirogyra calcarea Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 226.

Vegetative cells 37–42μ x 40–120μ, with plane end walls; 1 chromatophore, making 2 to 5 turns in the cell; conjugation scalariform; tubes formed by both gametangia; receptive gametangium inflated only on the outer side; zygospores ellipsoid, 40–55μ x 58–80μ; median spore wall smooth, yellow.

United States: Alabama, Birmingham, sinkholes in limestone.

Similar in form to *S. borgeana* but larger in all dimensions.

21. Spirogyra bullata Jao 1935. *Sinensia.* **6**, p. 588, Pl. 4, Fig. 55.

Vegetative cells 19–22μ x 41–83μ, with plane end walls; 1 chromatophore, making 1.5–5.5 turns in the cell; conjugation scalariform; tubes formed by both gametangia; sterile cells bullate up to 64μ in diameter and occurring in rows up to 25 cells long; fertile cells cylindric or slightly enlarged; zygospores ellipsoid, 22–29μ x 31–35(–51)μ; spore wall smooth, yellow at maturity. (Pl. XXII, Fig. 13.)

China, Szechwan.

Differs from *S. pratensis* in the shorter spores and absence of inflated fertile cells.

22. Spirogyra pratensis Transeau 1914. *Amer. Jour. Bot.* **1**, p. 292.

Vegetative cells 17–20μ x 80–240μ, with plane end walls; 1 chromatophore (rarely 2), making 1 to 8 turns; reproducing commonly by both zygospores and aplanospores; conjugation scalariform and lateral; tubes formed by both gametangia; fertile cells enlarged or fusiform-inflated to 38μ; sterile cells cylindric or inflated up to 90μ in diameter; spores in most cells ellipsoid, in others ovoid, or cylindric-ovoid, 24–36μ x 50–70μ; median spore wall yellow, smooth. (Pl. I, Fig. 7; Pl. XXII, Figs. 14–18.)

United States: Iowa; Wisconsin; Arkansas; Illinois; Michigan; Kentucky; Ohio.

China, Peiping (Jao Coll.), Nanking (Li Coll.).

The occurrence of globosely swollen sterile cells and the presence of lateral and scalariform conjugation together with aplanospore formation in most collections and sometimes in a single pair of filaments give character to this species.

23. Spirogyra affinis (Hassall) Petit 1880. *Les Spirogyres des environs de Paris,* p. 18, Pl. 3, Figs. 13–14.

Vegetative cells 25–30 μ x 35–90 μ, with plane end walls; 1 chromatophore, making 1 to 3.5 turns; conjugation lateral and scalariform; tubes formed by both gametangia; fertile cells globosely inflated; sterile cells not inflated; zygospores ellipsoid, 28–33 μ x 30–50 μ; median spore wall yellow, smooth.

United States: Michigan; Alaska.

Widely reported from Europe; Jamaica; China, Kiangsi.

24. Spirogyra catenaeformis (Hassall) Kützing 1849. *Species Algarum,* p. 438.

Vegetative cells 24–32 μ x 50–135 μ, with plane end walls; 1 chromatophore, making 1 to 6 turns; reproduction by both zygospores and aplanospores; conjugation scalariform and lateral; tubes formed by both gametangia; fertile cells enlarged or inflated, fusiform, sterile cells also inflated; zygospores and aplanospores ellipsoid, 27–33 μ x 55–90 μ; median spore wall yellow, smooth. (Pl. XXII, Fig. 12; Pl. XXIV, Fig. 16.)

United States: Generally distributed throughout.

Widely distributed in Europe; reported from China, India, and from East and South Africa.

Distinguished from *S. affinis* by the longer vegetative cells and the greatly inflated sterile cells; from *S. suecica* by the symmetrical fusiform inflation of the fertile cells and the ellipsoid spores; from *S. subsalina* by the yellow spores, generally smaller dimensions, and the less marked inflation of the fertile cells.

25. Spirogyra subsalina Cedercreutz 1924. *Acta Soc. pro Fauna et Flora Fennica.* 55 (2), p. 4, Fig. 2.

Vegetative cells 28–38 μ x 70–190 μ, with plane end walls; 1 chromatophore, making 2 to 4.5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated to 49–56 μ; zygospores ellipsoid, 28–38 μ x 42–76 μ; median spore wall brown, smooth. (Pl. XXII, Fig. 9.)

United States: Mississippi, Natchez, April, 1925.

Finland.

26. Spirogyra flavescens (Hassall) Kützing 1849. *Species Algarum,* p. 438.

Vegetative cells 10–14 μ x 30–50 μ, with plane end walls; 1 chromatophore, making 1 to 3 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated; zygospores ovoid, 20–23 μ x 25–40 μ; median spore wall yellow, smooth. (Pl. XXIII, Fig. 1.)

United States: Michigan; Massachusetts; Florida.

Widely distributed in Europe; reported from Australia.

27. Spirogyra subsalsa Kützing 1845. *Phycologia Germanica,* p. 222.

Vegetative cells 22–26μ x 35–100μ, with plane end walls; 1 chromatophore, making 2 to 3 turns; conjugation scalariform; tubes formed largely by the male gametangia, fertile cells inflated; zygospores ovoid, 18–27μ x 30–52μ; median spore wall yellow-brown, smooth. (Pl. XXIII, Fig. 2.)

United States: Wisconsin (Prescott Coll.); Florida.

Sweden; Holland; France; Czechoslovakia; Java.

28. Spirogyra paludosa Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 167, Fig. 170.

Vegetative cells 18–20μ x 55–78μ, with plane end walls; 1 chromatophore; conjugation scalariform; tubes formed by both gametangia; fertile cells somewhat swollen; sterile cells cylindric; zygospores ovoid, 24μ x 46–48μ; median spore wall golden-brown, smooth. (Pl. XXIII, Fig. 3.)

Czechoslovakia.

29. Spirogyra mirabilis (Hassall) Kützing 1849. *Species Algarum,* p. 438.

Vegetative cells 23–29μ x 70–200μ, with plane end walls; 1 chromatophore, making 4 to 7 turns; reproduction by aplanospores, *very* rarely by scalariform conjugation; tubes formed by both gametangia; sporangia enlarged or inflated; aplanospores and zygospores ovoid, less frequently varying to ellipsoid, 23–29μ x 50–83μ; median spore wall yellowish-brown, smooth. (Pl. XXIII, Fig. 4.)

United States: From Colorado, Wisconsin, and Texas, to Maine and North Carolina.

Widely distributed in Europe; recorded from Siberia, Manchuria, China, and Afghanistan. See also *S. aplanospora* (No. 38), and *S. maravillosa* (No. 65). Only a few zygospores have been seen among the hundreds of aplanosporic filaments studied.

30. Spirogyra longata (Vaucher) Kützing 1843. *Phycologia Generalis,* p. 279. Vaucher. *Histoire des Conferves,* Pl. 6. 1803. Includes *S. circumscissa* Czurda 1932, not *S. longata* (Vaucher) Czurda.

Vegetative cells 26–38μ x 45–280μ, with plane end walls; 1 chromatophore, making 2 to 5 turns; conjugation scalariform and lateral; tubes formed by both gametangia; zygospores ovoid, varying in some

cells to globose, 28–38μ x 50–83μ; median spore wall yellow, smooth. (Pl. XXIII, Fig. 5.)

United States: Common throughout.

Widely distributed in Europe, reported from East and South Africa, Asia, South America, and Australia. In Kentucky (McInteer Coll.) this species was found hybridizing with *S. porticalis.*

The distinctive features of this very common species are the ovoid spores and the nearly cylindric sporiferous cells.

31. Spirogyra oltmannsii Huber-Pestalozzi 1930. "Algen aus dem Knysnawalde in Südafrica." *Zeitsch. f. Bot.* **23**, p. 448.

Vegetative cells 23–27μ x 70–125μ, with plane end walls; 1 chromatophore, zygospores unknown; sporangia cylindric; aplanospores ovoid, 22–26μ x 30–42μ; median spore wall outwardly [?] scrobiculate. Described from immature specimens. (Pl. XXIII, Fig. 6.)

South Africa.

32. Spirogyra suecica Transeau 1934. *Ohio Jour. Sci.* **34**, p. 420. (=*S. varians* var. *gracilis*) Borge 1923. *Ark. Bot.* **6**, p. 11, Pl. 1, Fig. 2.

Vegetative cells 26–29μ x 80–175μ, with plane end walls; 1 chromatophore, making 1 to 4.5 turns; conjugation scalariform or rarely lateral between some cells; tubes formed by both gametangia; fertile cells inflated on both sides, usually more on the conjugating side, up to 60μ; zygospores usually ovoid, 32–39μ x 38–60μ; median spore wall yellow, smooth. (Pl. XXIII, Fig. 7.)

United States: Iowa; Ohio; Florida.

Sweden; France.

33. Spirogyra gallica Petit 1880. *Les Spirogyres des environs de Paris,* p. 23, Pl. 6, Figs. 1–3.

Vegetative cells 72–75μ x 150–500μ, with plane end walls; 1 chromatophore, making 4 to 8 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ovoid to ellipsoid, 62–66μ x 90–110μ; median spore wall yellow, smooth. (Pl. XXIII, Fig. 8.)

France; Belgium; Germany.

This is the largest of the *Spirogyras* with 1 chromatophore; differs from *S. condensata* of about the same dimensions in the ovoid spores and the much longer vegetative cells.

34. Spirogyra lacustris Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 176, Fig. 182.

Vegetative cells $38–44\mu$ x $105–160\mu$, with plane end walls; 1 chromatophore; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or very slightly swollen; zygospores ovoid, $42–45\mu$ x $70–80\mu$; median spore wall golden-brown, smooth, with suture more or less prominent. (Pl. XXIII, Fig. 10.)

Austria.

Certainly very close to *S. porticalis,* perhaps merely a clone; apparently differs in the brown spores with prominent sutures.

35. Spirogyra porticalis (Müller) Cleve 1868. *Försök till en monografi. Nova Acta Reg. Soc. Sci. Upsali.* Ser. 3, **6**, p. 22, Pl. 5, Figs. 8–9.

Vegetative cells $40–50\mu$ x $66–200\mu$, with plane end walls; 1 chromatophore, making 3 to 5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or enlarged; zygospores mostly ovoid to globose-ovoid, $38–50\mu$ x $50–83\mu$; median spore wall yellow, smooth. (Pl. XXIII, Fig. 9.)

United States: Very common in the eastern half.

Widely distributed on all the continents. Found hybridizing with *S. varians* at Charleston, Illinois. Hybrid segregates were also present. See *Amer. Nat.,* **53**, pp. 109–19, 1919.

36. Spirogyra sahnii Randhawa 1938. *Proc. Indian Acad. Sci.* **8**, pp. 339–41.

Vegetative cells $48–60\mu$ x $40–74\mu$, with plane end walls; 1 chromatophore, making 1 or 2 turns in the cell; conjugation lateral; tubes formed by both gametangia; fertile and sterile cells inflated; zygospores ovoid, $22–36\mu$ x $44–68\mu$; median wall [?] yellow, smooth; aplanospores similar, $20–24\mu$ x $22–36\mu$.

India, Punjab, Dasuya, March, 1931.

In the original description the median spore wall is described as "bluish-green." This appearance is probably due to light refraction and colored spore contents. Named for Birbal Sahni of Lucknow University.

37. Spirogyra lutetiana Petit 1879. *Brébissonia.* **1**, p. 79, Pl. 6.

Vegetative cells $27–40\mu$ x $70–250\mu$, with plane end walls; 1 chromatophore, making 3 to 7 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells more or less variable, cylindric, enlarged, or slightly inflated; zygospores polymorphic, varying from globose to ellipsoid and irregular, $25–44\mu$ x $35–165\mu$; median spore wall yellow-brown, smooth. (Pl. XXIII, Figs. 11–13.)

United States: Utah; North Dakota; other records very doubtful.

Widely reported from Europe and Asia; also South Africa.

Probably none of the species names of *Spirogyra* has been more fre-

quently misapplied than this one. Looking over the named collections one finds *S. lutetiana* attached to all sorts of forms in which the cells and spores are irregular, although Petit's description and figures are perfectly clear.

38. SPIROGYRA APLANOSPORA Randhawa 1938. *Proc. Indian Acad. Sci.* **8**, pp. 336–37.

Vegetative cells 20–26μ x 40–90μ, with plane end walls; 1 chromatophore, making 3 to 6 turns; fertile and sterile cells irregularly inflated; no conjugation seen; reproduction by aplanospores which are ovoid to globose, 24–30μ x 30–50μ; median wall brown, smooth. (Pl. XXIII, Figs. 17–18.)

India, Punjab, Dasuya, January, 1929.

The dimensions suggest that this is an ecological form of *S. mirabilis* (Hassall) Kützing. When *Spirogyras* are growing in water of warm temperature and low oxygen content they frequently have distorted cells, and Randhawa's figures are typical of this condition.

39. SPIROGYRA POLYMORPHA Kirchner 1878. *Algen. Kryptogamenflora Schlesien,* p. 124.

Vegetative cells 22–30μ x 45–230μ, with plane end walls; 1 or rarely 2 chromatophores, making 1 to 10 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated to 26–64μ; zygospores polymorphic, varying from ellipsoid to ovoid and globose, 22–32μ x 25–35μ; median spore wall yellow, smooth. (Pl. XXIII, Figs. 14–15.)

Widely reported in Europe. Recently figured and completely described by Jao from Szechwan, China. (*Sinensia.* **6**, p. 589, Pl. 5, Figs. 56–57. 1935.)

40. SPIROGYRA VELATA Nordstedt 1873. "Beskriftung öfver en nyart af Slagtet Spirogyra." *Lunds Univ. Arsskrift.* **9**, p. 1, Pl. 1.

Vegetative cells 29–41μ x 60–200μ, with plane end walls; 1 or rarely 2 chromatophores, making 2.5 to 6 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or somewhat enlarged; zygospores mostly ovoid to cylindric-ovoid, rarely ellipsoid, 37–57μ x 60–100μ; outer wall of 2 layers, of which the second is transparent and scrobiculate; the median is chitinous, yellow-brown, smooth. (Pl. XXIV, Fig. 1.)

United States: Iowa; Illinois; Kentucky; Indiana.

Germany; Russia; South Africa; China.

The original description of this species gives but 1 chromatophore. Nevertheless, in Nordstedt's collection from Lund (1882) 2 chromatophores are present in some of the cells. Petit states that the diameter of the vegetative cells of the specimens collected at Paris ran as high at 54μ. Possibly his collection included another species.

41. Spirogyra occidentalis (Transeau) Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 183.

Vegetative cells $40–50\mu$ x $125–300\mu$, with plane end walls; chromatophores 1, 2, or 3, making 2 to 6 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile gametangia cylindric or inflated to 66μ; zygospores ovoid to cylindric-ovoid, $36–56\mu$ x $57–105\mu$; median spore wall smooth, yellow-brown; outer wall of 2 layers, of which the inner is hyaline, scrobiculate. (Pl. XXIV, Fig. 2.)

United States: Iowa; Illinois; Indiana; Ohio; Kentucky.

Canada, British Columbia (Phycoth. Bor.-Amer., No. 961).

Resembles *S. velata* but has larger dimensions throughout.

42. Spirogyra luteospora Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 181.

Vegetative cells $22–24\mu$ x $55–90\mu$, with plane end walls; 1 chromatophore; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or enlarged by the spores; zygospores ovoid to cylindric-ovoid, $25–26\mu$ x $38–46\mu$; median spore wall golden-brown, scrobiculate; pits about 2μ in diameter. (Pl. XXIV, Fig. 3.)

Bohemia.

43. Spirogyra sulcata Blum 1943. *Amer. Jour. Bot.* **30**, p. 783, Figs. 9–11.

Vegetative cells $37–46\mu$ x $50–160\mu$, with plane end walls; 1(–2) chromatophores, with prominent median furrow, making 2 to 5 turns in the cells; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated on the outer side; zygospores ovoid, $43–46\mu$ x $52–62\mu$; median spore wall thick, brown, and reticulate. (Pl. XXIV, Fig. 4.)

United States: Wisconsin, Madison.

44. Spirogyra westii Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 224. *S. porticalis* var. *africana* G. S. West 1907. *Jour. Linn. Soc. of London Bot.* **38**, p. 105.

Vegetative cells $40–41\mu$ x $60–160\mu$, with plane end walls; 1 chromatophore, making 3 to 5 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells enlarged; zygospores ovoid, about 58μ x 93μ; median spore wall finely wrinkled, or corrugate.

Africa, Tanganyika.

45. Spirogyra obovata Jao 1935. *Sinensia.* **6**, p. 596, Pl. 7, Fig. 73.

Vegetative cells $25–29\mu$ x $70–182\mu$, with plane end walls; 1 chromatophore (rarely 2), making 2.5–6 turns in the cell; conjugation

scalariform; tubes formed by both cells; reproduction by zygospores and aplanospores; zygospores ovoid, 29–35μ x 44–73μ; aplanospores ovoid, 29–32μ x 38–42μ; median wall punctate, yellow at maturity. (Pl. XXIV, Fig. 5.)

China, Szechwan, November 15, 1933.

46. Spirogyra asiatica Czurda 1931. *Süsswasserflora Mitteleuropa.* 9, p. 185. 1932.

Vegetative cells 46–51μ x 100–160μ, with plane end walls; 1 chromatophore (rarely 2); conjugation lateral; tubes formed by both cells; fertile cells enlarged; zygospores ovoid, 60–65μ x 80–120μ; median spore wall dark brown, and minutely granulose; suture more or less prominent. (Pl. XXIV, Fig. 6.)

Central Tibet, altitude 17,000 feet.

47. Spirogyra lagerheimii Wittrock 1889. In Wittrock and Nordstedt Algae Exsiccatae, Nos. 961 and 962. *Bot. Notiser* 1889. p. 165.

Vegetative cells 25–33μ x 75–150μ, with plane end walls; 1 chromatophore, usually narrow, making .5 to 4 turns; conjugation scalariform and lateral; tubes formed by both cells; fertile cells cylindric or enlarged; zygospores ellipsoid with more or less pointed ends, 25–38μ x 50–100μ; median spore wall yellowish-brown, finely punctate. (Pl. XXIV, Fig. 7.)

United States: Illinois; Ohio; Massachusetts; New Hampshire.

Sweden; Germany; Latvia; Finland.

In the many collections seen, the chromatophores were uniformly narrow and formed open spirals.

48. Spirogyra taftiana Transeau 1944. *Ohio Jour. Sci.* **44**, p. 243.

Vegetative cells 18–25μ x 50–96μ, with plane end walls; 1 chromatophore, making 2–4 turns in the cell; conjugation scalariform; tubes formed by both gametangia; receptive gametangia enlarged or fusiform-inflated; sterile cells often bulliform; zygospores ellipsoid, 24–34μ x 42–80μ; median wall distinctly and densely punctate; pits more or less angular, yellow. (Pl. XXIV, Fig. 8.)

United States: Texas, Huntsville (Taft Coll.).

Named for C. E. Taft, The Ohio State University, author of many papers on fresh-water algae.

49. Spirogyra perforans Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 228, Pl. 21, Fig. 57.

Vegetative cells 14–18μ x 72–120μ, with plane end walls; 1 chromatophore, making 3 to 6 turns; conjugation scalariform; tubes formed

by both gametangia; fertile cells enlarged; zygospores ellipsoid, 25–29μ x (50–)65–69μ; median spore wall yellow-brown, coarsely punctate. (Pl. XXIV, Fig. 9.)

United States: Florida (Tiffany Coll.).

50. Spirogyra porangabae Transeau 1938. *Amer. Jour. Bot.* 25, p. 525.

Vegetative cells 11–15μ x 65–145μ, with plane end walls; 1 chromatophore, making 4 to 9 turns in the cell; conjugation scalariform; tubes formed by both gametangia; receptive gametangium enlarged or slightly inflated; sterile cells inflated, often bulliform; zygospores ellipsoid, 21–27μ x 47–54μ; median wall at first smooth, at maturity irregularly but distinctly punctate, yellow-brown. (Pl. XXIV, Fig. 11.)

Brazil, Ceará, Porangaba, October 8, 1935 (Drouet Coll.).

This species resembles *S. bullata Jao,* but is smaller and the spore wall is punctate.

51. Spirogyra minutifossa Jao 1935. *Trans. Amer. Micros. Soc.* 54, pp. 3–4, Pl. 1, Fig. 5.

Vegetative cells 16–19μ x 55–176μ, with plane end walls; 1 chromatophore, making 2–6.5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells fusiform-inflated; zygospores ellipsoid with rather pointed ends, 22–26μ x 35–48μ; median spore wall irregularly and minutely grooved, yellow at maturity. (Pl. XXIV, Fig. 10.)

United States: Massachusetts, Nonamesset Island, July 14, 1933.

Nova Scotia (Hughes Coll.).

52. Spirogyra skujae Randhawa 1938. *Proc. Indian Acad. Sci.* 8 (4), Sec. B, p. 338.

Vegetative cells 14–17μ x 84–140μ, with plane end walls; 1 chromatophore, making 3–5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated medially to 26–34μ; zygospores ellipsoid, 24–30μ x 40–52μ; median spore wall reticulate, yellow-brown. (Pl. XXIV, Fig. 12.)

India, Fyzabad, Upper Punjab, February 7, 1937.

Resembles *S. hoehnei* Borge in the form of the fertile cells, but has smaller dimensions throughout and the median spore wall is reticulate, not punctate. This description includes *S. reticuleana.*

53. Spirogyra hoehnei Borge 1925. *Ark. Bot.* 19, p. 13, Pl. 2, Fig. 1.

Vegetative cells 26–29μ x 150–350μ, with plane end walls; 1 chromatophore, making 4 to 9 turns; conjugation scalariform; tubes formed by both cells; fertile cells inflated toward the middle to 52μ; zygospores

ellipsoid, 32–37μ x 50–65μ; median spore wall yellow, irregularly and coarsely punctate. (Pl. XXIV, Fig. 13.)

United States: Kentucky (McInteer Coll.).

South America, Paraguay; South Africa.

54. Spirogyra robusta (Nygaard) Czurda 1932. *Trans. Roy. Soc. S. Africa.* **20**, Pt. II. *Süsswasserflora Mitteleuropa.* 9, p. 187.

Vegetative cells 29–35μ in diameter, with plane end walls; 1 chromatophore; conjugation scalariform; tubes formed by both cells; fertile cells inflated, 43–65μ in diameter; zygospores ellipsoid, 32–60μ x 54–104μ; median spore wall yellowish-brown, with faint, irregular scrobiculations. (Pl. XXIV, Figs. 14–15.)

South Africa.

55. Spirogyra subpapulata Jao 1935. *Sinensia.* **6**, p. 597, Pl. 7, Figs. 74–75.

Vegetative cells 22–26μ x 41–166μ, with plane end walls; 1 chromatophore, making 2–7 turns in the cell; reproduction by either zygospores or aplanospores; conjugation scalariform; tubes formed by both cells; sterile cells usually swollen to 58μ in diameter; zygospores ellipsoid, with pointed ends, 21–29μ x 41–60μ; aplanospores subglobose or ellipsoid, 22–26μ x 32–48μ; median wall finely and densely punctate, yellow at maturity. (Pl. XXV, Figs. 1–2.)

China, Szechwan, December, 1933, and January, 1934 (Jao Coll.).

This species resembles *Spirogyra papulata* Jao, but has smaller vegetative cells and punctate spores.

56. Spirogyra papulata Jao 1935. *Sinensia.* **6**, p. 598, Pl. 7, Figs. 76–78.

Vegetative cells 28–32μ x 64–176μ, with plane end walls; chromatophore single, containing large pyrenoids; conjugation scalariform; tubes formed by both gametangia; fertile cells usually shortened and inflated on the conjugating side, up to 55μ in diameter; sterile cells sometimes swollen to 64μ; zygospores ellipsoid, very rarely subglobose, 22–32μ x 35–55μ; median spore wall irregularly reticulate, golden yellow at maturity. (Pl. XXV, Figs. 3–5.)

China, Szechwan, January, 1933.

57. Spirogyra scrobiculata (Stockmayer) Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 182.

Vegetative cells 30–40μ x 30–90μ, with plane end walls; 1 chromatophore; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated on the conjugating side; zygospores ellipsoid,

34–38 μ x 58–68 μ; median spore wall yellow to yellow-brown; scrobiculate. (Pl. XXIV, Fig. 17; Pl. XXV, Figs. 6–7.)

United States: Utah; Wisconsin; Illinois; Kentucky; Michigan; Ohio; Mississippi.

Austria.

Differs from *S. varians* in the scrobiculate median spore wall.

58. SPIROGYRA APHANOSCULPTA Skuja 1937. *Hedwigia.* 77, p. 55.

Vegetative cells 32–38 μ x 50–119 μ, with plane end walls; 1 chromatophore, making 1 to 4 turns; conjugation scalariform; tubes formed by both gametangia; female gametangia 43–150 μ in length, cylindric or inflated on the conjugating side; sterile cells sometimes inflated; zygospores ellipsoid to cylindric-ellipsoid, 31–40 μ x 43–81 μ; median spore wall yellow-brown, punctate with angular and irregular pits. (Pl. XXV, Fig. 8.)

United States: New Hampshire, Hanover (Blum Coll.).

Greece, Taygetus; Africa, Cape Colony (Stephens Coll.).

59. SPIROGYRA KAFFIRITA Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 228, Fig. 59.

Vegetative cells 39–45 μ x 65–140 μ, with plane end walls; 1 chromatophore; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated on the inner side; zygospores ellipsoid, 32–40 μ x 45–60(–75) μ; median spore wall yellow, shallow-granulate, reticulate. (Pl. XXV, Fig. 11.)

Africa, Cape Colony (Stephens Coll.).

60. SPIROGYRA TUBERCULATA Lagerheim 1896. Wittrock and Nordstedt Algae Exsiccatae, No. 1379.

Vegetative cells 35–37 μ x 70–165 μ, with plane end walls; 1 chromatophore; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated on both sides; zygospores ellipsoid with rounded ends, 30–38 μ x 50–67 μ; median spore wall yellow, irregularly verrucose.

Sweden, Uppsala.

The inflation of the fertile cells and the smaller dimensions distinguish this species from *S. australensis*.

61. SPIROGYRA DAEDALEA Lagerheim 1888. *Nuova Notarisia,* p. 592.

Vegetative cells 33–36 μ x 180–330 μ, with plane end walls; 1 chromatophore, making 2 to 3.5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or enlarged to 36–45 μ, and shortened; zygospores ellipsoid, 30–40 μ x 50–96 μ; median spore wall yellow-brown, very irregularly corrugate. (Pl. XXV, Figs. 9–10.)

United States: Iowa.

Germany; Latvia; Yugoslavia; Finland; India.

In the original collection there is a deposit of brown granules between the outer and median walls.

62. Spirogyra daedaleoides Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, pp. 180–81. Skuja. *Acta Horti Bot. Univ. Latviensis.* 4, p. 39. 1929.

Vegetative cells 30–44μ x 65–240μ, with plane end walls; 1 chromatophore, making 2 to 8 turns; conjugation scalariform and lateral; tubes formed by both gametangia; fertile cells enlarged or slightly inflated (–50μ); zygospores ellipsoid, 30–46μ x 46–90μ; median spore wall brown, with prominent irregular reticulate ridges. (Pl. XXV, Figs. 13–15.)

United States: Wisconsin (Prescott Coll.); Illinois; Ohio.

Latvia, Saaremaa.

63. Spirogyra australensis Möbius 1895. In Bailey, *Queensland Flora. Dept. of Agric. Bot. Bull.* 1, p. 34, Pl. 9, Fig. 1.

Vegetative cells about 50μ x 100–150μ, with plane end walls; 1 chromatophore, making 2.5 to 3 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or enlarged; zygospores ellipsoid, 40–45μ x 74–77μ; median spore wall yellowish-brown, finely verrucose. (Pl. XLI, Fig. 12.)

Australia, Queensland.

Distinguished from *S. tuberculata* Lagerheim by the larger dimensions throughout and by the cylindric or enlarged fertile cells; from *S. daedalea* Lagerheim by the verrucose median spore wall.

64. Spirogyra labyrinthica Transeau 1934. *Ohio Jour. Sci.* 34, p. 420. (*S. daedalea* var. *major* Hirn 1913) in Borge, *Zygnemales. Süsswasserflora Deutschland.* 9, p. 27.

Vegetative cells 50–63μ x 150–400μ, with plane end walls; 1 chromatophore; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or enlarged; zygospores ellipsoid, 43–58μ x 80–118μ; median spore wall brown, distinctly reticulate.

Germany, Würzburg.

SPECIES WITH PLANE END WALLS
TWO OR MORE CHROMATOPHORES

65. Spirogyra maravillosa Transeau 1938. *Amer. Jour. Bot.* 25, p. 525.

Vegetative cells 24–29μ x 108–260μ, with plane end walls; 2 or 3 chromatophores, making 2 to 5 turns in the cell; conjugation unknown;

aplanospores broadly ellipsoid, 28–36μ x 43–60(–72)μ; median wall smooth, yellow-brown; sporangia enlarged or slightly inflated. (Pl. XXVI, Figs. 1–2.)

Brazil, Belém, July 9, 1935 (Drouet Coll.).

This species resembles Number 29, *S. mirabilis* (Hassall) Kützing but differs in having 2 or 3 chromatophores.

66. Spirogyra irregularis Nägeli 1849. In Kützing, *Species Algarum*, p. 440; also 1855, *Tab. Phycoth.*, 5, Pl. 23, Fig. 2.

Vegetative cells 32–37μ x 65–250μ, with plane end walls; 2 to 4 chromatophores, making .5 to 1 turn; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ellipsoid to cylindric-ellipsoid, 30–36μ x 45–90μ; median spore wall yellowish-brown, smooth. (Pl. XXVI, Fig. 3.)

United States: Illinois; Missouri (Drouet Coll.).

Widely reported from western and central Europe.

67. Spirogyra fuellebornei Schmidle 1902. Engler's *Bot. Jahrb.* 32, p. 76, Pl. 3, Fig. 2.

Vegetative cells 40–42μ x 120–240μ, with plane end walls; 3 chromatophores, making 1 to 2 turns; conjugation scalariform and lateral; tubes formed by both gametangia; fertile cells cylindric; zygospores ellipsoid, more or less pointed, 32–44μ x 50–80μ; median spore wall smooth, yellow-brown. (Pl. XXVI, Fig. 4.)

United States: Wisconsin (Prescott Coll.).

Africa; Nyassa Lake region; Central America, Panama.

68. Spirogyra microspora Jao 1935. *Sinensia.* 6, pp. 593–94, Pl. 6, Fig. 65.

Vegetative cells 35–38μ x 64–131μ, with plane end walls; 2 chromatophores, broad with large pyrenoids, making 1.5–3.5 turns in the cell; conjugation lateral; tubes formed by both gametangia; fertile cells cylindric; zygospores ellipsoid, 29–32μ x 51–61μ; median wall smooth, yellow at maturity. (Pl. XXVI, Fig. 5.)

China, Szechwan, November, 1933.

69. Spirogyra hollandiae Taft 1947. *Ohio Jour. Sci.* 47, p. 173.

Vegetative cells 36–41μ x 60–192μ, with plane end walls; 2 chromatophores, broad with large pyrenoids, making 1.5–2.5 turns in the cell; conjugation usually lateral; tubes formed by both gametangia; sterile cells sometimes inflated; receptive gametangia cylindric or enlarged; zygospores ellipsoid with rounded ends, 38–42μ x 62–78μ; median wall smooth, bright yellow at maturity. (Pl. XXVI, Figs. 6–7.)

Dutch New Guinea, Hollandia (Robert Sigafoos Coll.), Biak (Britton Coll.).

In the Biak collection several instances of scalariform conjugation were found. See also Number 72.

70. Spirogyra submarina (Collins) Transeau 1915. *Ohio Jour. Sci.* **16**, p. 25. Collins. 1909. *Green Algae of North America,* p. 110.

Vegetative cells 21–32μ x 65–175μ, with plane end walls; 2 to 3 chromatophores, making 1.5 to 3 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells enlarged; zygospores ellipsoid, 31–37μ x 56–120μ; median spore wall yellowish-brown, smooth.

United States: Massachusetts; Connecticut.

Bermuda; China, Peiping and Nanking (Li Coll.).

71. Spirogyra rivularis (Hassall) Rabenhorst 1868. *Flora Europaea Algarum.* **3**, p. 243.

Vegetative cells 36–41μ x 100–400μ, with plane end walls; 2 to 3 chromatophores, making 2.5 to 3.5 turns in the cells; conjugation scalariform, rare; tubes formed by both gametangia; fertile cells shortened, cylindric or enlarged; zygospores ellipsoid, 35–42μ x 60–100μ; median spore wall yellow or brownish-yellow, smooth. (Pl. XXVI, Fig. 8.)

United States: Kansas; Iowa; Michigan; Alabama; Kentucky.

Widely distributed in Europe, South Africa, New Guinea, and several provinces of China.

Most of the early records of this species are based on vegetative material. It is said to occur in running water, attached to submerged objects. In the vegetative condition it certainly cannot be distinguished from *S. decimina,* which in America is also frequently attached and floating in small streams. See note under *S. turfosa* (No. 79).

72. Spirogyra biformis Jao 1935. *Sinensia.* **6**, pp. 594–95, Pl. 6, Fig. 66.

Vegetative cells 38–48μ x 64–150(–190)μ, with plane end walls; chromatophores (1–)2–3, making 1.5 to 4.5 turns; conjugation usually lateral, rarely scalariform; tubes formed by both gametangia; fertile cells cylindric or slightly enlarged, sometimes shortened to 38μ; sterile cells some times swollen to 58μ in diameter; zygospores ellipsoid with rounded ends, 36–51μ x 60–83μ; median spore wall yellow, smooth. (Pl. XXVI, Figs. 9–10.)

China, Szechwan; New Guinea (Robert Sigafoos Coll.); Philippines, Leyte (Britton Coll.); Brazil (Drouet Coll.). Compare with Number 69.

In the collection from Leyte conjugation is scalariform, elsewhere lateral. In one of the collections from Leyte a few cells have 4 chromatophores.

73. Spirogyra hyalina Cleve 1868. *Nova Acta Reg. Soc. Sci. Upsali.* Ser. 3, 6, p. 17, Pl. 3, Figs. 1–6.

Vegetative cells 45–60 μ x 80–240 μ, with plane end walls; chromatophores, 2, 3, or 4, making .5 to 3 turns; conjugation lateral or scalariform; tubes formed by both gametangia; fertile cells cylindric, or slightly inflated; zygospores ellipsoid, more or less pointed, 45–60 μ x 60–130 μ; median spore wall brown, smooth; aplanospores similar, somewhat smaller. (Pl. XXVI, Figs. 11–12.)

United States: Iowa; Mississippi.

Sweden; Puerto Rico; India; China.

Cleve's figures show the characteristic long conjugating tubes. In lateral conjugation the form of the tube is almost unique.

74. Spirogyra pseudoneglecta Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 194.

Vegetative cells 55–60 μ x 130–240 μ, with plane end walls; 3 chromatophores; conjugation lateral and scalariform; tubes formed by both gametangia; fertile cells cylindric or slightly swollen; zygospores ellipsoid, 50–52 μ x 95–100 μ; median spore wall reddish-brown, smooth. (Pl. XXVI, Figs. 13–14.)

Moravia.

75. Spirogyra columbiana Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 190.

Vegetative cells 48–54 μ x 90–180 μ, with plane end walls; chromatophores (1–)3; conjugation scalariform; tubes formed by both gametangia; fertile and sterile cells cylindric; zygospores ellipsoid, about 50 μ x 70 μ; median spore wall smooth, yellow-brown, suture distinct. (Pl. XXVI, Fig. 15.)

South America, Colombia; South Africa; Java.

76. Spirogyra angolensis Welwitsch 1897. *Jour. Bot.* 35, p. 41.

Vegetative cells 49–62 μ x 60–200 μ, with plane end walls; 2 or 3 chromatophores, making 2 to 3 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or enlarged; zygospores ellipsoid with somewhat pointed ends, 52–57 μ x 84–100 μ; median spore wall smooth, yellow.

United States: Iowa (Tiffany Coll.).

South Africa, Angola; China, Yünnan.

77. Spirogyra welwitschii W. & G. S. West 1897. *Jour. Bot.* 35, p. 41.

Vegetative cells 65–75 μ x 40–150 μ, with plane end walls; 2 (rarely 3) chromatophores, making 1 to 2 turns; conjugation scalariform; tubes

formed by both gametangia; fertile cells cylindric; zygospores broadly ellipsoid, 57–58 μ x 69–71 μ; median spore wall smooth.

South Africa, Angola, July, 1854.

78. Spirogyra parvispora Wood 1869. *Proc. Amer. Phil. Soc.* **11**, p. 139. 1872. *Smithson. Contribu. Knowledge.* **19**, p. 169, Pl. 15, Fig. 7.

Vegetative cells about 75 μ x 150–300 μ, with plane end walls; 4 chromatophores, making 1.5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells not inflated; spores ellipsoid, 50 μ x 75–100 μ; median spore wall brown, smooth. (Pl. XXVI, Fig. 16.)

United States: Florida.

79. Spirogyra turfosa Gay 1884. *Essai Monogr. Conjug.*, p. 187, Pl. 4, Fig. 3.

Vegetative cells 68–78 μ x 68–350 μ, with plane end walls; 3–4 chromatophores, making 1.5 to 4 turns; fertile cells cylindric; conjugation scalariform; tubes formed by both gametangia; zygospores ellipsoid, pointed, 65–78 μ x 120–140 μ; median spore wall smooth, yellow. (Pl. XXVI, Fig. 17.)

United States: Kansas; Mississippi; Alabama.

Galicia.

In the 3 collections from the United States this species was associated with *S. rivularis,* which it resembles in all characteristics except size. It would be interesting to know the relative chromosome complements of these 2 species. It might be a mutation from *S. rivularis* due to a single gene change.

80. Spirogyra nitida (Dillwyn) Link 1833. *Handbuch,* Pt. 3, p. 262.

Vegetative cells 70–80 μ x 90–300 μ, with plane end walls; 3–5 chromatophores, making .5 to 1.5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or enlarged; zygospores ellipsoid, rarely somewhat ovoid, 60–76 μ x 90–177 μ; median spore wall brown, smooth. (Pl. XXVII, Figs. 1–2.)

United States: Many records from Iowa and Wisconsin to Massachusetts, south to Mississippi and Florida.

Europe; India; Australia; China; South Africa.

This species consists of many overlapping forms that differ only slightly in dimensions, hence the spread in cell diameters. Near Starkville, Mississippi, I found this species hybridizing with *S. crassa.* In the undrained pond there were also the resulting hybrid segregates.

81. Spirogyra hymerae Britton & Smith 1942. *Ohio Jour. Sci.* **42**, p. 70.

Vegetative cells 83–92μ x 43–256μ, with plane end walls; 2–4 chromatophores, usually 3, making .5-2 turns in the cell; conjugation scalariform; tubes formed by both gametangia; receptive gametangia cylindric or slightly enlarged; zygospores mostly ellipsoid, 53–79μ x 83–128μ; all walls smooth; median wall yellow. (Pl. XXVII, Fig. 3.)

United States: Indiana, Sullivan County, September 10, 1936.

Resembles *S. setiformis* but differs in chromatophore complement and in the proportionately smaller spores.

82. Spirogyra setiformis (Roth) Kützing 1845. *Phycologia Germanica,* p. 223.

Vegetative cells 90–115μ x 100–225μ, with plane end walls; chromatophores 4, making .5 to 4 turns in the cells; conjugation scalariform; tubes formed by both gametangia; receptive gametangia cylindric; zygospores ellipsoid, 85–100μ x 115–160μ; median wall brown and smooth. (Pl. XXVII, Figs. 4–5.)

United States: Iowa; Illinois; Indiana; Pennsylvania; New Jersey; Massachusetts.

Widely reported from European countries.

This is certainly not the species described by Czurda (1932) which has 6 to 10 chromatophores. The earliest figures published agree with those of Petit (1880) in having 4 chromatophores. In any event, the description given here characterizes a species that is very common in the east central states and agrees with Borge's interpretation in the first edition of the *Süsswasserflora,* 9. In the *Handbuch der Pflanzenanatomie* (Bd. VI, 2 Teil., p. 65) Czurda (1937) figures this species with 4 chromatophores.

83. Spirogyra elliptica Jao 1935. *Sinensia.* 6, p. 596, Pl. 6, Fig. 72.

Vegetative cells 115–128μ x 128–568μ, with plane end walls; 4 to 6 chromatophores, making 1 to 3 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric and shortened; zygospores ellipsoid with pointed ends, 82–106μ x 144–202μ; median wall smooth, yellow-brown. (Pl. XXVII, Fig. 6.)

China, Szechwan, January, 1933.

84. Spirogyra wollnyi de Toni 1889. *Sylloge Algarum.* 2, p. 754. Wollny. *Hedwigia.* 1887, p. 166 (as *S. elegans*).

Vegetative cells 90–100μ x 270–350μ, with plane end walls; 6 to 8 chromatophores, making 2 to 2.5 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ellipsoid, 90–100μ x 140–190μ; median wall yellow-brown, smooth, with distinct suture.

Germany, Dresden; South Africa, Queenstown Cape, July, 1930 (Stephens Coll.).

This imperfectly described species of Wollny has been completed by the additional data gleaned from Miss Stephens' collection.

85. SPIROGYRA WRIGHTIANA Transeau 1938. *Amer. Jour. Bot.* 25, p. 527, Figs. 16–17.

Vegetative cells 130–165 μ x 275–430(–690) μ, with plane end walls; 6–8 chromatophores, making 1–3 turns in the cell; conjugation unknown; aplanospores mostly ellipsoid, 100–126 μ x 158–206 μ; sporangia cylindric and of the same dimensions as the vegetative cells; spore walls in the material seen probably not mature, smooth and colorless. (Pl. I, Figs. 4–5; Pl. XXVII, Figs. 7–8.)

South America, Brazil, Parahiba, July 14, 1934 (Drouet Coll.).

Very similar in appearance to the preceding species; and, as is usual in aplanosporic species, the spores are small compared with the volume of the vegetative cells in which they form.

86. SPIROGYRA YUNNANENSIS Li 1939. *Bull. Fan Mem. Inst. Biol., Botany.* 9, p. 224, Pl. 27, Fig. 2.

Vegetative cells 98–110 μ x 224–268 μ, with plane end walls; chromatophores 6–8, making 2–4 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric and shortened; zygospores ellipsoid, 88–96 μ x 120–180 μ; median spore wall smooth, yellow. (Pl. XXVII, Fig. 9.)

China, Yünnan.

87. SPIROGYRA HATILLENSIS Transeau 1936. *Brittonia.* 2, p. 171.

Vegetative cells 120–130 μ x 108–450 μ, with plane end walls; 6 to 8 chromatophores, having .5 to 4 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; sterile cells more or less swollen; zygospores ellipsoid, 85–125 μ x 130–160 μ; median spore wall brown, smooth. Spores small compared with volume of gametangium. (Pl. XXVII, Fig. 10.)

United States: North Carolina (Whitford Coll.).

Puerto Rico, Hatillo, February, 1915 (Wille Coll.).

88. SPIROGYRA ELLIPSOSPORA Transeau 1914. *Amer. Jour. Bot.* 1, p. 294.

Vegetative cells 125–150 μ x 125–500 μ, with plane end walls; 3 to 8 chromatophores, making .4 to 5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ellipsoid, more or less pointed, 100–140 μ x 160–255 μ; median spore wall smooth, yellow-brown. (Pl. XXVII, Fig. 11.)

Generally distributed in the eastern half of the United States, but no reports from the southern coastal plain.

Central China.

89. Spirogyra splendida G. S. West 1914. *Mem. Soc. Neuchateloise Sci. Nat.* 5, pp. 1013–51.

Vegetative cells 158–166μ x 210–330μ, with plane end walls; 5 to 6 chromatophores, making 1.5 to 2 turns in the cells; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ellipsoid, about 135μ x 216μ; median spore wall yellow, smooth. (Pl. XXVII, Fig. 17.)

South America, Colombia, Cundinamarca.

90. Spirogyra emilianensis Bonhomme 1858. *Sur quelques algues d'eau douce,* p. 7, Pl. 2, Fig. 2.

Vegetative cells 50–60μ x 100–200μ, with plane end walls; 4 to 5 chromatophores, making .2 to 2.5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ovoid, 52–60μ x 90–124μ; median spore wall brown, smooth. (Pl. XXVII, Fig. 12.)

United States: Massachusetts, Boston (Bullard Coll.).
France.

91. Spirogyra exilis W. & G. S. West 1907. *Ann. Roy. Bot. Gard., Calcutta.* 6, p. 186.

Vegetative cells 27–30μ x 42–120μ, with plane end walls; 2 broad chromatophores, making 1.5 to 2 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells enlarged on the inner face, or cylindrical; sterile cells often greatly inflated to 49μ; zygospores ovoid to oblong, 27–30μ x 36–45μ; median spore wall yellow, smooth. (Pl. XXVII, Fig. 13.)

Burma.

92. Spirogyra distenta Transeau 1934. *Ohio Jour. Sci.* 34, p. 420. Fritsch. *Trans. Roy. Soc. S. Africa.* 9, p. 46, as *S. decimina* var. *inflata.*

Vegetative cells 48–52μ x 81–180μ, with plane end walls; 2 chromatophores, making 1.5 to 2 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or enlarged; sterile cells inflated to 75μ; zygospores ovoid, 49–55μ x 50–100μ; median spore wall yellow, smooth.

United States: Illinois; Kentucky; Ohio.
South Africa.

93. Spirogyra triplicata (Collins) Transeau 1944. *Ohio Jour. Sci.* 44, p. 243. Collins, F. S. *S. decimina* var. *triplicata.* Phycoth. Bor.-Amer., No. 960. *Green Algae of North America.* p. 110. 1912.

Vegetative cells 35–45 μ x 140–200 μ, with plane end walls; 3 chromatophores, making 1.5 to 3 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ovoid, 34–48 μ x 48–54 μ; median spore wall yellow, smooth.

United States: California; Illinois; Kentucky; Massachusetts.

94. Spirogyra siamensis nom. nov. *Bot. Tidsskrift.* 24, p. 161, as *S. decimina* var. *tropica* W. & G. S. West. Transeau 1944. *Ohio Jour. Sci.* 44, p. 243 as *S. tropica,* a name preoccupied by Kützing.

Vegetative cells 46–50 μ x 100–250 μ with plane end walls; 3 chromatophores, making 2.5 to 4.6 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ovoid, 46–50 μ x 81–124 μ; median spore wall yellow, smooth.

Siam, Island of Koh Chang.

95. Spirogyra neglecta (Hassall) Kützing 1849. *Species Algarum,* p. 441.

Vegetative cells 55–67 μ x 100–300 μ, with plane end walls; 3 chromatophores, making 1 to 2.5 turns; conjugation scalariform and lateral; tubes formed by both gametangia; fertile cells enlarged, or often greatly enlarged or inflated, and spores may develop at right angles to the filament; zygospores and aplanospores ovoid, 54–64 μ x 75–100 μ; median spore wall yellow, smooth. (Pl. XXVII, Figs. 14–15.)

United States: Colorado; Illinois; Indiana; Ohio; Kentucky; Massachusetts.

Germany; Finland; Czechoslovakia; Macedonia; Java; Siam; South Africa; China; India; West Indies.

The species described by Ripart (1876) as *S. ternata* frequently has been found associated with this species, and not infrequently at opposite ends of the same filaments. The short crowded cells of "ternata" are the result of more rapid cell division just preceding conjugation.

96. Spirogyra decimina (Müller) Kützing 1843. *Phycologia Generalis,* p. 279. Wittrock and Nordstedt Algae Exsiccatae, No. 1372.

Vegetative cells 32–42 μ x 66–150 μ, with plane end walls; 2–3 chromatophores, making 1 to 2 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or enlarged; zygospores ovoid to globose, 31–40 μ x 31–68 μ; median spore wall yellow, smooth. (Pl. XXVII, Fig. 16.)

United States: Common in most states from Colorado eastward.

Europe; Asia; Africa; West Indies; Java; South America.

Under this name Czurda (1932) has described a species with ellipsoid

spores and 1–2 chromatophores. This description obviously disregards all previous descriptions and exsiccatae.

97. Spirogyra plena (W. & G. S. West) Czurda 1932. *Süsswasser-flora Mitteleuropa.* 9, p. 193. *Ann. Roy. Bot. Gard., Calcutta.* **6**, p. 187. 1907.

Vegetative cells 38–44μ x 57–88μ, with plane end walls; 2 or 3 chromatophores; conjugation scalariform and lateral; tubes large and formed by both gametangia; fertile cells cylindric or enlarged on the conjugating side; zygospores ovoid, 40–44μ x 64–73(–88)μ; median spore wall yellow, smooth. (Pl. XXVIII, Figs. 1–2.)

United States: Iowa; Indiana; Kentucky; Ohio.

Asia, Burma; China, Yünnan; India, Bombay.

98. Spirogyra szechwanensis Jao 1935. *Sinensia.* **6**, p. 595, Pl. 6, Fig. 69. *Amer. Jour. Bot.* **23**, p. 55. 1936.

Vegetative cells 75–90μ x 125–240μ, with plane end walls; 4 chromatophores, rarely 2 or 3, making 1–2 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ellipsoid to ovoid, 57–68μ x 100–210μ; median spore wall smooth, yellow at maturity. (Pl. XXVIII, Fig. 3.)

China, Chungking.

99. Spirogyra jugalis (Fl. Dan.) Kützing 1845. *Phycologia Germanica,* p. 223.

Vegetative cells 75–103μ x 80–300μ, with plane end walls; 3 to 4 chromatophores, making 1 to 2 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or enlarged; zygospores ovoid, 87–108μ x 120–155μ; median spore wall brown, smooth. (Pl. XXVIII, Fig. 4.)

United States: Minnesota; Iowa; Illinois; Michigan; Massachusetts.

Europe; China.

100. Spirogyra margaritata Wollny 1877. *Hedwigia.* **16**, p. 164.

Vegetative cells 100–120μ x 150–400μ, with plane end walls; 13 to 15 chromatophores, making .25 to .5 turns: conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or inflated to 165μ; zygospores ovoid, 92–125μ x 140–200μ; median spore wall smooth, brown. (Pl. XXVIII, Fig. 5.)

Germany, Dresden.

Thirty years ago Dr. Nordstedt sent me dried material of this species collected by R. Wollny in 1877, which I assume to be a part of the type collection. Most of the spores are immature, but are globose only when seen along the long axis. The above details are based on this collection and complete the description.

101. Spirogyra polytaeniata Strasburger 1888. *Ueber Kern- und Zell-theilung. Jena.*

Vegetative cells 150–189μ x 180–240μ, with plane end walls; 12 to 14 chromatophores, making .5 turn; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ellipsoid, about 120μ x 158μ; median spore wall smooth, brown.

Switzerland, Zürich.

102. Spirogyra jaoensis Randhawa 1938. *Proc. Indian Acad. Sci.* **8**, pp. 358–59.

Vegetative cells 44–56μ x 90–125μ, with plane end walls; 4 to 6 chromatophores, making about .5 turn in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells somewhat inflated on the conjugating side; zygospores ovoid, 54–58μ x 72–80μ; median spore wall smooth, brown.

India, Fyzabad, November, 1936.

This species differs very little from *S. emilianensis* (No. 90). It was named for Chin-Chih Jao, who has contributed not only numerous descriptions of new Zygnemataceae, but excellent drawings of intricate spore wall structures.

103. Spirogyra baileyi Schmidle 1896. *Flora.* **82**, pp. 302–3, Pl. 9, Fig. 2.

Vegetative cells 20–24μ x 128–200μ, with plane end walls; 2 chromatophores, making 3 to 4 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated to 32μ; zygospores ellipsoid, 28μ x 48–50μ; median spore wall smooth. (Pl. XXVIII, Fig. 7.)

Australia, Queensland.

104. Spirogyra buchetii Petit 1913. *Bull. soc. bot. de France.* **60**, pp. 40–43.

Vegetative cells 44–48μ x 100–140μ, with plane end walls; 2 chromatophores, making 2.5 to 4 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells shortened and inflated to 51μ; zygospores ellipsoid with rounded ends, variously placed in the fertile cells giving the appearance of being polymorphic, 48–51μ x 72μ; median spore wall smooth, yellow.

United States: Indiana, Sullivan County (Ben Smith Coll.).

Morocco, Tangier; China, Shantung (Li Coll.).

105. Spirogyra bichromatophora (Randhawa) Transeau 1944. *Ohio Jour. Sci.* **44**, p. 243. *Proc. Indian Acad. Sci.* **8**, pp. 353–54, Fig. 48. 1938 (as *S. gallica* var. *bichromatophora*).

Vegetative cells 60–75 μ x 96–160 μ, with plane end walls; 2 chromatophores, making 4 to 6 turns; conjugation scalariform; large tubes formed by both gametangia; fertile cells cylindric or enlarged; zygospores ellipsoid, 54–60 μ x 80–90 μ; median spore wall smooth, brown. (Pl. XXVIII, Fig. 6.)

India, Fyzabad, May, 1938.

106. Spirogyra rhizoides Randhawa 1938. *Proc. Indian Acad. Sci.* 8, pp. 354–56.

Vegetative cells 26–28 μ x 75–125 μ, with plane end walls; chromatophores 2–3, making 1–2 turns in the cell; rhizoids well developed, made up of 1 or 2 cells with chromatophores; conjugation scalariform; tubes formed by both gametangia; fertile cells slightly inflated; zygospores ovoid, 36–38 μ x 52–58 μ; median spore wall thick, smooth, pale yellow.

India, Hoshiarpur, March, 1930.

In the original description, the median spore wall is given as "bluish." This appearance may have resulted from diffraction of light. I did not find it in the specimens examined.

107. Spirogyra dubia Kützing 1855. *Tabulae phycologicae.* 5, p. 8, Pl. 24, Fig. 4.

Vegetative cells 40–50 μ x 60–250 μ, with plane end walls; 2 to 3 chromatophores, making 2 to 8.5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated; zygospores ovoid, 42–50 μ x 54–67 μ; median spore wall yellow-brown, smooth. (Pl. XXVIII, Fig. 8.)

United States: Iowa; Illinois; Michigan; Pennsylvania; Massachusetts. Europe; Australia; South Africa; China.

108. Spirogyra puncticulata Jao 1935. *Trans. Amer. Micros. Soc.* 54, p. 4, Pl. 1, Fig. 9.

Vegetative cells 16–22 μ x 48–240 μ, with plane end walls; filaments attached by rhizoids; chromatophores 2, rarely 1, making 1.5 to 5 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells fusiform or cylindrically inflated to 29–36 μ; zygospores ovoid, 25–32 μ x 41–58 μ; median wall densely punctate, yellow. (Pl. XXVIII, Fig. 9.)

United States: Massachusetts, Woods Hole.

109. Spirogyra aequinoctialis G. S. West 1907. *Jour. Linn. Soc. of London Bot.* 38, p. 105, Pl. 5, Figs. 1–2.

Vegetative cells 23–25 μ x 90–150 μ, with plane end walls; 3 (rarely 2) chromatophores, making 1–1.5 turns; conjugation scalariform; tubes

formed by both gametangia; fertile cells inflated, oblong; zygospores ovoid, or oblong-ovoid, 41–43μ x 52–71μ; median wall densely scrobiculate. (Pl. XXVIII, Fig. 10.)

United States: Wisconsin (Prescott Coll.).

Central Africa.

110. Spirogyra rhizopus Jao 1936. *Amer. Jour. Bot.* 23, p. 55, Figs. 10–12.

Vegetative cells 25–32μ x 80–250μ, with plane end walls; 2 chromatophores, making 1.5 to 4 turns; basal cell with much expanded and irregularly lobed holdfast; conjugation scalariform; tubes formed by both gametangia; fertile cells quadrangularly inflated, sometimes oblong in form, to 57μ; zygospores ellipsoid, 35–42μ x 64–100μ; outer spore wall thick, lamellose, colorless; median spore wall brown, irregularly reticulate. (Pl. XXVIII, Figs. 11–13.)

China, Peiping, July, 1927.

111. Spirogyra dictyospora Jao 1935. *Sinensia.* 6, p. 599, Pl. 8, Fig. 84.

Vegetative cells 28–32μ x 55–144μ, with plane end walls; chromatophores 3, sometimes 2, making 2–5 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells enlarged up to 55μ; zygospores ovoid, 41–55μ x 61–103μ; median spore wall reticulate, yellow to yellow-brown. (Pl. XXVIII, Fig. 14.)

China, Chungking, February, 1930.

112. Spirogyra natchita Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 225.

Vegetative cells 32–36μ x 120–200μ, with plane end walls; 1 to 3 (mostly 2) chromatophores; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated to 62μ; zygospores ovoid, 56–60μ x 90–114μ; median spore wall yellow-brown, punctate and reticulate.

United States: Texas and Mississippi.

113. Spirogyra fossa Jao 1935. *Trans. Amer. Micros. Soc.* 54, p. 3, Pl. 1, Fig. 6.

Vegetative cells 19–22μ x 96–192μ, with plane end walls; 2 chromatophores, making 1 to 5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells enlarged to 33μ; zygospores ellipsoid, 27–32μ x 48–77μ; median spore wall yellow-brown at maturity, with irregular, tortuous grooves, or corrugations. (Pl. XXVIII, Figs. 15–16.)

United States: Massachusetts, Pasque Island, June 26, 1924.

114. SPIROGYRA SCHMIDTII W. & G. S. West 1902. *Bot. Tidsskrift.* 24, p. 161, Figs. 43–45.

Vegetative cells 30–35 μ x 210–350 μ, with plane end walls; 2 to 3(4) chromatophores, making 2.5 to 4 turns; fertile cells inflated to 59 μ; conjugation scalariform; tubes formed by both gametangia; zygospores ellipsoid, 43–46 μ x 88–118 μ; median spore wall yellow-brown, scrobiculate. (Pl. XXVIII, Figs. 19–20.)

United States: Texas and Florida.

Siam, Koh Chang.

The conjugating tubes frequently appear to have been formed by the male gametangium, due to the growth of the wall of the receptive gametangium.

115. SPIROGYRA MIAMIANA Taft 1944. *Ohio Jour. Sci.* 44, p. 238.

Vegetative cells 20–25 μ x 150–340 μ, with plane end walls; 3 chromatophores (rarely 2), making 1.5 to 5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells enlarged to 41 μ, length 71 to 172 μ; zygospores ellipsoid to cylindric-ellipsoid, 30–39 μ x 92 μ; median spore wall composed of 2 layers; the outer layer wrinkled; the inner layer finely scrobiculate, yellow-brown at maturity.

United States: Florida, Miami Beach and Winter Park.

This species is at first attached to various underwater objects in flowing water.

116. SPIROGYRA SMITHII Transeau 1934. *Trans. Amer. Micros. Soc.* 53, p. 225.

Vegetative cells 30–35 μ x 220–360 μ, with plane end walls; 3 to 4 chromatophores, making 1 to 3 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells enlarged; zygospores ellipsoid, 45–52 μ x 75–102 μ; median spore wall yellow-brown, of 2 layers—outer, thin, wrinkled; inner, reticulate. (Pl. XXVIII, Figs. 17–18.)

United States: Arkansas to Texas, east to New York and Florida.

Named for Professor Ben H. Smith, Indiana State Teachers College at Terre Haute, who collected the type specimens, and added many new records to the Indiana algal flora.

117. SPIROGYRA CHUNGKINGENSIS Jao 1935. *Sinensia.* 6, p. 600, Pl. 8, Figs. 85–86. *Amer. Jour. Bot.* 23, p. 58. 1936.

Vegetative cells 22–26 μ x 80–170 μ, with plane end walls; 3 chromatophores, making 1 to 3 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated; zygospores ellipsoid, 35–39 μ x 54–68 μ; median wall of 2 layers, of which the outer

is thin, brownish and wrinkled, the inner, brown, and irregularly reticulate. (Pl. XXIX, Figs. 1–2.)

China, Chungking, August, 1930.

118. Spirogyra orientalis W. & G. S. West 1907. *Ann. Roy. Bot. Gard., Calcutta.* **6**, p. 186.

Vegetative cells 30–31 μ x 90–160 μ, with plane end walls; 3 chromatophores, making 1 to 1.5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated, 57–65 μ; zygospores ellipsoid, more or less pointed, 38–42 μ x 61–67 μ; median spore wall minutely scrobiculate, brown. (Pl. XXIX, Fig. 3.)

United States: Michigan, Cheboygan County (Taft Coll.).

Burma; China, Yünnan (Li Coll.).

119. Spirogyra subcylindrospora Jao 1935. *Sinensia.* **6**, p. 598, Pl. 7, Figs. 79–80.

Vegetative cells 25–32 μ x 96–228 μ, with plane end walls; 2 to 3 (rarely 4) chromatophores, making 1 to 1.5 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or enlarged; zygospores ellipsoid to cylindric-ellipsoid with rounded ends, 32–38 μ x 58–96 μ; median spore wall brown, thick, reticulate. (Pl. XXIX, Figs. 4–5.)

United States: Florida (Tiffany Coll.).

China, Szechwan.

120. Spirogyra castanacea G. C. Couch 1944. *Ohio Jour. Sci.* **44**, p. 277.

Vegetative cells 34–37 μ x 100–173 μ, with plane end walls; 2 to 3 chromatophores, making 2 to 3 turns in the cell; conjugation scalariform; tubes formed by both gametangia; receptive cell inflated on both sides; zygospores mostly broadly ellipsoid, rarely ovoid, 48–52 μ x 69–73 μ; median spore wall chestnut brown, strongly reticulate.

United States: Arkansas, Boston Mountain region.

121. Spirogyra mienningensis Li 1940. *Bull. Fan Mem. Inst. Biol., Botany.* **10**, p. 61.

Vegetative cells 42–48 μ x 102–208 μ, with plane end walls; chromatophores 2 or 3, making 1–4 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated up to 74 μ; zygospores ellipsoid, 52–59 μ x 70–88 μ; outer spore wall of 2 layers, the outermost thin, smooth, transparent; the inner, thin and wrinkled; median spore wall granulose to verrucose, yellow-brown at maturity. (Pl. XXIX, Fig. 6.)

China, Yünnan, Mienning, December 10, 1938.

122. Spirogyra shantungensis Li 1936. *Bull. Fan Mem. Inst. Biol., Botany.* **7**, p. 60.

Vegetative cells 46–52μ x 184–320μ, with plane end walls; chromatophores 3, making 2 to 4 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated up to 70μ and shortened; zygospores ellipsoid, with somewhat rounded ends, 48–56μ x 96–140μ; median spore wall double, outer nearly colorless, wrinkled; inner, brown, finely and irregularly reticulate. (Pl. XXIX, Fig. 7.)

China, Tsingtao, Shantung, October, 1934.

123. Spirogyra braziliensis (Nordstedt) Transeau 1915. *Ohio Jour. Sci.* **16**, p. 26. Wittrock and Nordstedt Algae Exsiccatae, No. 360, as *S. lineata* var. *braziliensis.*

Vegetative cells 50–60μ x 125–300μ, with plane end walls; 3 chromatophores, making 1 to 3 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric, shortened; zygospores ellipsoid, 54–60μ x 80–90μ; median spore wall minutely verrucose, yellow-brown.

United States: Texas; Iowa; Mississippi.

South America; China, Shantung.

124. Spirogyra pulchrifigurata Jao 1935. *Sinensia.* **6**, p. 601, Pl. 8, Figs. 91–92. *Amer. Jour. Bot.* **23**, p. 57, Figs. 15–17. 1936.

Vegetative cells 42–58μ x 64–192μ, with plane end walls; 3 to 4 chromatophores, making 1.5 to 4 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated up to 83μ; zygospores ellipsoid, with more or less rounded ends, 48–64μ x 70–109μ; median spore wall yellow-brown, irregularly reticulate. (Pl. XXIX, Figs. 8–9.)

United States: Louisiana (Taft Coll.).

China, Szechwan, February, 1930.

125. Spirogyra torta Blum 1943. *Amer. Jour. Bot.* **30**, p. 783, Figs. 3–5.

Vegetative cells 49–56μ x 270–600μ, with plane end walls; 3 to 5 chromatophores, making 1 to 4 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or enlarged; zygospores ellipsoid, 67–72μ x 110–135μ; outer spore wall wrinkled, loose; median spore wall dark yellow, conspicuously pitted-reticulate. (Pl. XXIX, Fig. 10.)

United States: Massachusetts, Trout Pond, Megansett, July 27, 1942.

126. Spirogyra quadrilaminata Jao 1935. *Sinensia.* **6**, p. 600,

Pl. 8, Figs. 87–88. *Amer. Jour. Bot.* **23**, p. 58, Figs. 25–26. 1936.

Vegetative cells 38–58μ x 112–256μ, with plane end walls; 3 to 4 chromatophores, making 1 to 3.5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ellipsoid to cylindric-ellipsoid, with more or less rounded ends, 43–54μ x 64–102μ; median spore wall of 2 layers; outer, brown and densely wrinkled; inner, brown, finely punctate, and at times finely and irregularly reticulate. (Pl. XXIX, Figs. 11–13.)

United States: Florida; Tennessee; Texas.
Puerto Rico; Brazil; China, Szechwan.

127. Spirogyra rhizobrachialis Jao 1935. *Sinensia.* **6**, p. 599, Pl. 7, Figs. 81–83. *Amer. Jour. Bot.* **23**, p. 57, Figs. 18–21. 1936.

Vegetative cells 40–45μ x 114–240μ, with plane end walls; 3 to 5 chromatophores, making 1.5 to 2.5 turns; in some portions of the filament each sterile cell produces a lateral rhizoid-shaped attachment with a more or less lobed hapteron; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric, sometimes shortened and enlarged; zygospores ellipsoid with more or less rounded ends, 38–60μ x 58–100μ; median spore wall yellow-brown, finely and irregularly reticulate. (Pl. XXIX, Figs. 14–16.)

United States: Wisconsin (Prescott Coll.).
China, Chungking, February, 1930.

128. Spirogyra paraguayensis Borge 1903. *Ark. Bot.* **1**, p. 280.

Vegetative cells 41–45μ x 80–200μ, with plane end walls; 3 to 4 chromatophores, nearly straight, or making .5 turn; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric, shortened; zygospores ellipsoid, 37–42μ x 58–65μ; median spore wall irregularly corrugate, yellow-brown. (Pl. XXIX, Figs. 17–18.)

South America, Paraguay.

129. Spirogyra subreticulata Fritsch 1921. *Trans. Roy. Soc. S. Africa.* **9**, p. 48.

Vegetative cells 50–54μ x 150–400μ, with plane end walls; 3 to 4 chromatophores, making .5 to 3 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or enlarged; zygospores ellipsoid to somewhat ovoid, 42–54μ x 60–124μ; outer median spore wall irregularly reticulate, yellow-brown; inner wall brown, up to 9μ thick. (Pl. XXIX, Figs. 19–21.)

United States: Iowa; Indiana.
South Africa; China, Shantung (Li Coll.).

130. Spirogyra minor (Schmidle) Transeau 1944. *Ohio Jour. Sci.* **44**, p. 243. Schmidle. *Hedwigia.* **40**, p. 46 (as *S. malmeana* var. *minor*).

Vegetative cells 55–60μ x 150–300μ; 3 (rarely 4) chromatophores; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ellipsoid, 50–60μ x 90–180μ; median spore wall irregularly reticulate, yellow-brown.

United States: Indiana (Ben Smith Coll.); Mississippi, Jackson; Texas (Davidson Coll.).

Brazil; South Africa (Stephens Coll.); China, Szechwan (Li Coll.).

This species name occurred in two editions of my mimeographed key to this genus where the date was given as 1925. There was no formal publication in a journal until 1944. Between these two dates all the above records accumulated.

131. Spirogyra brunnea Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 197. Fritsch & Rich. *Trans. Roy. Soc. S. Africa.* **18**, p. 51. 1929 (as *S. reinhardii* var. *africana*).

Vegetative cells 56–71μ x 85–280μ, with plane end walls; 3 to 5 chromatophores, making 2 to 3 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells shortened, and slightly inflated on both sides; zygospores ovoid, 55–66μ x 73–94μ; median spore wall brown, intricately reticulate. (Pl. XXX, Figs. 1–2.)

South Africa, Transvaal and Griqualand.

132. Spirogyra scripta Nygaard 1932. *Trans. Roy. Soc. S. Africa.* **20**, p. 144, Fig. 48.

Vegetative cells 51–64μ x 220–300μ, with plane end walls; 4 to 5 chromatophores, making about 2 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated to 67–71μ, shortened; zygospores ellipsoid, more or less pointed, 54–60μ x 91–107μ; median spore wall brown, with an intricate pattern of branched, short, dark crevices and corrugations. (Pl. XXX, Figs. 3–4.)

South Africa, Transvaal.

133. Spirogyra fluviatilis Hilse 1863. In Rabenhorst's *Algen Europas,* No. 1476. *Flora Europaea Algarum.* **3**, p. 243. 1868. Wolle. *Freshwater Algae,* p. 216, Pl. 136, Figs. 1–3.

Vegetative cells 30–45μ x 70–240μ, with plane end walls; 3 to 4 chromatophores, making 1.5 to 3.5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells shortened and inflated to 70μ; zygospores ovoid, 47–85μ x 68–110μ; median spore wall brown, corrugate, or finely wrinkled. Remarkable branched rhizoids develop from some of the cells. (Pl. XXX, Fig. 5.)

United States: Widely distributed from Colorado to the east coast.

Germany and France; widely reported in other countries but not necessarily this species; China and India.

This species is frequent in streams and ponds in the northern Central States, attached to underwater objects at first, later floating free. Although described by Hilse in 1863, it was not reported in fruit until 1887 by Wolle. Zygospores were described by Borge from the upper Rhine region in 1894. These two publications establish the above description for *S. fluviatilis*. Under this name Czurda (1932) described two forms of different dimensions with ellipsoid spores and 3–5 chromatophores and the tube formed by the male cell. His illustration, however, has 2 chromatophores and the tubes are formed by both gametangia. These plants evidently belong near *S. smithii* (No. 116). Krieger follows Czurda's description.

134. Spirogyra africana (Fritsch) Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 201.

Vegetative cells 50–60μ x 150–500μ, with plane end walls; 3 to 4 chromatophores, making 1.5 to 4 turns; conjugation scalariform; tubes formed by both gametangia; receptive cells enlarged or inflated on both sides up to 96μ; zygospores ovoid, 60–67μ x 78–90μ; median spore wall brown, irregularly and shallowly corrugate.

Africa, Cape Colony; Guatemala (Kellerman Coll.).

Very similar to *S. fluviatilis,* but has larger dimensions throughout.

135. Spirogyra notabilis Taft 1944. *Ohio Jour. Sci.* 44, p. 238.

Vegetative cells 30–37μ x 92–230μ, with plane end walls; 2, 3, or 4 chromatophores, making 1 to 3 turns in the cell; at conjugation the cell walls are notably thickened; conjugation scalariform between short gametangia; tubes formed by both gametangia, but more by the male; receptive gametangia enlarged near the spore; zygospores ovoid, 48–57μ x 78–105μ; median spore wall of 2 yellow-brown layers, of which the outer is conspicuously punctate, the inner, reticulate and finely verrucose.

United States: Texas, Austin, April 19, 1938.

The layers of the median wall are distinct and are among the most beautifully ornamented walls in the genus.

136. Spirogyra grossii Schmidle 1901. *Allgem. Bot. Zeitschr.* 7, p. 3.

Vegetative cells 40–42μ x 50–120μ, with plane end walls; 3 chromatophores, making 2 to 4 turns in the cell; conjugation scalariform; tubes apparently formed by the male gametangia; fertile cells inflated to 64μ; zygospores ovoid, 43–51μ x 64–118μ; median spore wall irregularly corrugate. (Pl. XXX, Fig. 6.)

Yugoslavia; Manchuria; India.

137. Spirogyra ovigera Montagne 1850. *Ann. sci. nat.* p. 305. *Sylloge generum specierumque,* Paris, p. 463. 1856.

Vegetative cells 38–42 μ x 60–280 μ, with plane end walls; 3 chromatophores, making 2 to 3 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated; zygospores ovoid, sometimes nearly ellipsoid, 45–52 μ x 75–100 μ; median spore wall granulose, brown.

United States: Texas (Davidson Coll.).

South America, French Guiana.

138. Spirogyra novae-angliae Transeau 1915. *Ohio Jour. Sci.* **16**, p. 26.

Vegetative cells 48–60 μ x 150–390 μ, with plane end walls; 3 to 5 chromatophores, making 2.5 to 4.5 turns; conjugation scalariform; fertile cells cylindric or enlarged; tubes formed by both gametangia; zygospores ovoid, 50–65 μ x 70–120 μ; median spore wall yellow, reticulate and finely punctate. (Pl. XXX, Fig. 7.)

United States: Iowa and Wisconsin to Louisiana, and eastward to Massachusetts.

139. Spirogyra anomala Rao 1937. *Jour. Indian Bot. Soc.* **16**, p. 285.

Vegetative cells 108–125 μ x 72–165 μ, with plane end walls; chromatophores 5 to 10; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ellipsoid, more or less pointed, 73–90 μ x 108–138(–165) μ; median wall thick, brown, and finely reticulate.

India: Sarnath, U.P.

140. Spirogyra verruculosa Jao 1936. *Amer. Jour. Bot.* **23**, p. 58.

Vegetative cells 105–120 μ x 259–420 μ, with plane end walls; 5 chromatophores, making 2 to 5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or slightly enlarged; zygospores ellipsoid to ovoid, 105–120 μ x 168–220 μ; median spore wall dark brown, distinctly verrucose. (Pl. XXX, Figs. 8–10.)

China, Hangchow, June, 1929.

141. Spirogyra malmeana Hirn 1896. Wittrock and Nordstedt Algae Exsiccatae, No. 1375.

Vegetative cells 76–91 μ x 160–300 μ, with plane end walls; 3 to 4 chromatophores, making 1.5 to 4 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ellipsoid,

65–83μ x 75–100μ; median spore wall yellow-brown, irregularly reticulate. (Pl. XXX, Figs. 14–16.)

Brazil, Mato Grosso, May, 1894.

142. Spirogyra propria Transeau 1915. *Ohio Jour. Sci.* **16**, p. 25.

Vegetative cells 60–68μ x 80–150μ, with plane end walls; 3 chromatophores, making .5 to 1 turn; conjugation lateral; tubes formed by both gametangia; fertile cells cylindric; zygospores ellipsoid, 42–60μ x 80–120μ; median spore wall irregularly pitted, yellow-brown.

United States: Illinois; Kentucky (McInteer Coll.).

In the collections seen the spores were uniformly oriented diagonally in the short receptive gametangia.

143. Spirogyra trachycarpa Skuja 1932. *Acta Horti Bot. Univ. Latviensis.* **7**, p. 63, Fig. 82.

Vegetative cells 110–123μ x 110–500μ, with plane end walls; 4 to 6(–8) chromatophores, making 1 to 2.5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated on the inner side; male gametangia 87–176μ long, female, 119–252μ; zygospores broadly ellipsoid, 87–108μ x 117–172(–204)μ; median spore wall thick, irregularly scrobiculate, color not given; outer spore wall thick, hyaline.

Latvia.

144. Spirogyra ghosei Singh 1938. *Jour. Indian Bot. Soc.* **17**, p. 382.

Vegetative cells 100–105μ x 225–390μ, with plane end walls; chromatophores 6 to 7; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ovoid, 90–103μ x 105–120μ; median spore wall thick, brown and closely reticulate. (Pl. XXV, Fig. 12.)

India, U.P., Gorakhpur, November 8, 1937.

145. Spirogyra punctulata Jao 1936. *Amer. Jour. Bot.* **23**, p. 57, Figs. 13–14.

Vegetative cells 70–83μ x 105–315μ, with plane end walls; filaments usually curved; 3 to 7 chromatophores, making .5 to 1.5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ellipsoid with pointed ends, 64–74μ x 83–179μ; median spore wall thick, finely punctate, and yellow at maturity. (Pl. XXX, Figs. 11–13.)

China, Poatin, August, 1929.

Jao in 1939 described a variety *macrospora,* with 4 chromatophores and thicker spores.

146. Spirogyra cylindrospora W. & G. S. West 1897. *Jour. Bot.* **35**, p. 42.

Vegetative cells 70–77μ x 100–300μ, with plane end walls; 4 chromatophores, making 1 to 3 turns; conjugation scalariform and lateral; tubes formed by both gametangia; fertile cells cylindric; zygospores cylindric-ovoid, 70–77μ x 78–98μ; median spore wall yellow, punctate-scrobiculate, thick.

Central Africa.

147. Spirogyra echinospora Blum 1943. *Amer. Jour. Bot.* **30**, p. 783, Figs. 1–2.

Vegetative cells 66–72μ x 50–125μ, with plane end walls; 6–7(–8) chromatophores, making .5 to 1.5 turns in the cell; conjugation scalariform; tubes wide and formed by both gametangia; fertile cells more or less inflated on the conjugating side; zygospores ovoid, 67–82μ x 98–150μ; median spore wall thick, brown-black, echinate. (Pl. XXX, Figs. 17–18.)

United States: New Hampshire.

148. Spirogyra diluta Wood 1869. *Proc. Amer. Phil. Soc.* (1869), p. 139. Phycoth. Bor.-Amer., No. 513.

Vegetative cells 70–85μ x 80–160μ, with plane end walls; 5 to 8 chromatophores, straight or making 1 turn; conjugation scalariform; tubes formed by both gametangia; fertile cells enlarged or inflated on the inner side; zygospores ovoid, 66–90μ x 90–130μ; median spore wall chestnut brown, verrucose-reticulate to verrucose. (Pl. XXX, Figs. 19–20.)

United States: Illinois to Massachusetts and Connecticut.

In Figure 19 note short gametangia with spores oriented at right angles to the filaments. Similar gametangia occur in species Numbers 141, 147, 149, 150, 151, also in Numbers 171, 176, and 177.

149. Spirogyra echinata Tiffany 1924. *Ohio Jour. Sci.* **24**, p. 180, Pl. 1, Fig. 1.

Vegetative cells 88–96μ x 84–106μ, with plane end walls; 4 to 7 chromatophores, making .5 to 1.5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells shortened and inflated on the conjugating side; zygospores ovoid, 68–85μ x 76–120μ, often placed transversely to the filament; median spore wall reticulate-echinate, brown. (Pl. XXXI, Figs. 1–2.)

United States: Iowa, Montgomery.

South Africa (Stephens Coll.).

150. Spirogyra reinhardii Chmielevski 1903. In Borge, *Süsswasserflora Deutschland.* 9, p. 31, Fig. 41.

Vegetative cells 108–117μ x 85–310μ, with plane end walls; 4 to 6 chromatophores, making .5 to 2 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated on the conjugating side; zygospores ovoid, 78–100μ x 115–175μ; median spore wall chestnut brown, irregularly reticulate. (Pl. XXXI, Figs. 3–5.)

Russia, Kharkov; Brazil.

151. Spirogyra hunanensis Jao 1940. *Sinensia.* **11**, p. 297, Pl. 4, Figs. 4–5.

Vegetative cells 88–100μ x 75–210μ, with plane end walls, and 8–10 nearly straight or slightly spiraled chromatophores; conjugation scalariform; tubes formed by both gametangia; receptive gametangia inflated on the conjugating side up to 150μ; zygospores ovoid, 88–105μ x 142–163μ; median spore wall yellow-brown, reticulate and verrucose, with verrucae up to 13μ in length. (Pl. XXXI, Fig. 6.)

China, Hunan.

SPECIES WITH SPORES LATERALLY COMPRESSED

152. Spirogyra discoidea Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 228.

Vegetative cells 39–42μ x 72–115μ, with plane end walls; 1 chromatophore; conjugation scalariform; tubes formed by both gametangia; receptive gametangia enlarged or inflated toward the middle; zygospores compressed-globose, 40–44μ x 56–65μ; median spore wall brown, smooth. (Pl. XXXI, Fig. 7.)

South Africa, Cape Town (E. Stephens Coll.).

153. Spirogyra sphaerospora Hirn 1895. *Acta Soc. pro Fauna et Flora Fennica.* **11** (10), p. 10.

Vegetative cells 43–45μ x 180–320μ, with plane end walls; 1 chromatophore, making about 3 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells greatly inflated (to 93–100μ) toward the middle; zygospores compressed-globose, 85–95μ in diameter; median spore wall yellowish-brown, smooth. (Pl. XXXI, Fig. 9.)

Finland, Lojo.

Cedercreutz (*Mem. Soc. pro Fauna et Flora Fennica,* **11**, p. 131) gives evidence from examination of material from Lojo that Hirn's species is identical with *S. pellucida* (No. 156). This species is, therefore, listed here tentatively on the basis of the single chromatophore. The published figures of these 2 species are certainly very similar. Hirn may have been in error concerning the number of chromatophores—a very unusual error for him.

154. Spirogyra sinensis Li 1933. *Ohio Jour. Sci.* **33**, p. 153, Pl. 1, Figs. 7–8.

Vegetative cells 22–24μ x 115–136μ, with plane end walls; 2 to 4 chromatophores, making 2.5 to 4.5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated toward the middle to about 50μ; zygospores lenticular, 38–45μ in diameter; median spore wall smooth, brown. (Pl. XXXI, Fig. 10.)

China, Hangchow.

155. Spirogyra frankliniana Tiffany 1934. *Trans. Amer. Micros. Soc.* **53**, p. 225. *Ohio Jour. Sci.* **24**, p. 65.

Vegetative cells 32–36μ x 80–120μ, with plane end walls; 3 to 4 chromatophores, making 1 to 3 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated toward the middle; zygospores lenticular, 40–56μ in diameter; median spore wall smooth, brown.

United States: Ohio, Franklin County, Baumgartner's Lake.

156. Spirogyra pellucida (Hassall) Kützing 1849. *Species Algarum,* p. 439. Hassall. *History of British Freshwater Algae.* p. 143, Pl. 25, Figs. 1–2.

Vegetative cells 40–50μ x 100–400μ, with plane end walls; 3 to 4 chromatophores, straight, or making .5 to 4 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated toward the middle; zygospores lenticular, 77–86μ in diameter; median spore wall smooth, brown. (Pl. XXXI, Fig. 8.)

United States: Iowa (Prescott Coll.).
England; Finland; China.

157. Spirogyra colligata Hodgetts 1920. *Ann. Bot.* **34**, p. 523, Pl. 22.

Vegetative cells 29–40μ x 240–640μ, with conspicuous collars between the cells; 4 to 6 chromatophores, usually 5, making .5 to 2.0 turns in the cell; conjugation scalariform, lateral, and terminal; tubes formed by both gametangia; fertile cells inflated at the middle up to 90–100μ; zygospores lenticular to lenticular-globose, 50–80(–90)μ in diameter; median spore wall verruculose, brown. (Pl. XXXI, Figs. 11–13.)

United States: Indiana, Laporte County (Britton Coll.), May 13, 1939.
England.

158. Spirogyra majuscula Kützing 1849. *Species Algarum,* p. 441.

Vegetative cells 50–80μ x 80–500μ, with plane end walls; (3–)5 to 8 chromatophores, straight or making .3 turn; conjugation scalariform and lateral; tubes formed by both gametangia; fertile cells shortened,

cylindric or slightly inflated; zygospores lenticular, 57–62μ x 45–60μ; median spore wall brown, smooth; aplanospores similar but smaller. (Pl. XXXI, Figs. 14–15.)

United States: Very abundant in late spring and summer throughout the northcentral states; also reported from Washington and Texas; and from the eastern states, New England to South Carolina.

Europe; China; South Africa; Brazil; Uruguay.

This is a complex group of elementary forms, differing in dimensions and numbers of chromatophores. However, among the many collections I have examined, the overlapping of form characteristics is so continuous from the smaller to the larger specimens that there seem to be no good bases for separation as varieties and forms. Czurda (1932, p. 204) discusses smaller and larger forms. Conard (*Beih. Bot. Zentralbl.* **55**, p. 184, 1936) proposed to remove certain of the species having lenticular spores from the genus *Spirogyra* under the generic name *Degagnya*. This proposal would require a restudy of all species of Zygnemataceae, since he introduces new criteria for the separation of genera. The species Conard designates as *D. majuscula* Conard is certainly not our species *S. majuscula* Kützing.

In 1884 Professor C. E. Bessey reported finding this species conjugating with *S. protecta*. Conjugation occurred in both directions and the zygospores formed were similar to those of the female filament.

159. Spirogyra submaxima Transeau 1914. *Amer. Jour. Bot.* **1**, p. 295, Pl. 27, Figs. 3–4.

Vegetative cells 70–110μ x 100–300μ, with plane end walls; 8 to 9 chromatophores making .1 to 1 turn; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric, enlarged, or slightly inflated; zygospores lenticular, 70–110μ x 50–75μ; median spore wall brown, smooth.

United States: Missouri and Mississippi eastward to Massachusetts.

China; India.

Found hybridizing with *S. maxima* at Charleston, Illinois.

160. Spirogyra glabra Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 206, Fig. 222.

Vegetative cells 145–153μ x 120–220μ, with plane end walls; 7 chromatophores; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores lenticular, about 120μ x 170μ; outer spore wall about 10μ thick, colorless; median spore wall about 20μ thick, yellow-brown, smooth. (Pl. XXXI, Fig. 16.)

Austria, Vienna.

161. Spirogyra bellis (Hassall) Cleve 1868. *Nova Acta Reg. Soc. Sci. Upsali.* Ser. 3, **6**, p. 18, Pl. 3, Figs. 2–5.

Vegetative cells 65–80μ x 90–350μ, with plane end walls; 5 to 6

chromatophores, making .1 to 1 turn; conjugation scalariform; tubes formed by both gametangia; fertile cells shortened and inflated; zygospores lenticular, 60–90μ x 48–60μ; median spore wall brown, irregularly pitted. (Pl. XXXI, Figs. 17–18.)

United States: Missouri to Massachusetts and Florida.

Europe; Australia; South Africa.

162. Spirogyra moebii Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 225. *S. maxima* var. *minor* Moebius. *Flora.* **75**, p. 421. 1892.

Vegetative cells 80–117 μ x 130–240μ, with plane end walls; 6 to 8 chromatophores, making .5 to 1 turn; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores lenticular, 74–100μ x 56–65μ; median spore wall yellow-brown, reticulate.

United States: Oklahoma (Taft Coll.).

Europe; Australia, Queensland.

163. Spirogyra oblata Jao 1936. *Amer. Jour. Bot.* **23**, p. 58, Figs. 29–31.

Vegetative cells 96–118μ x 80–256μ, with plane end walls; 9 to 13 chromatophores, nearly straight, or making up to .6 turn; conjugation scalariform; tubes formed by both gametangia; fertile cells shortened, cylindric; zygospores lenticular, 93–106μ x 64–70μ; outer wall thick, smooth, and lamellate; median spore wall yellow-brown, verrucose. (Pl. XXXII, Figs. 1–3.)

China, Hangchow, June, 1929.

164. Spirogyra formosa (Transeau) Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 203. *S. crassa* var. *formosa. Ohio Jour. Sci.* **16**, p. 27. 1915.

Vegetative cells 80–95μ x 80–270μ, with plane end walls; 6–12 chromatophores, making .5 to 1 turn in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores compressed-ovoid, 88–100μ x 120–150μ x 70–90μ; median spore wall brown, with irregular, shallow pits. (Pl. XXXII, Fig. 4.)

United States: Illinois, Ashmore, June 18, 1913.

Spores are broadly ovoid in one plane and narrowly ovoid when viewed at right angles.

165. Spirogyra jassiensis (Teodoresco) Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 203. *Beih. Bot. Zentralbl.* **21**, p. 189. 1907.

Vegetative cells 116–132μ x 116–250μ, with plane end walls; 8 to 9 chromatophores, making .5 to 1 turn; conjugation lateral; tubes formed

by both gametangia; fertile cells cylindric; zygospores lenticular to compressed-ovoid, 102–126μ x 140–154μ x 72–97μ; median spore wall brown, smooth. (Pl. XXXII, Fig. 5.)

Russia, Bessarabia.

166. SPIROGYRA AZYGOSPORA Singh 1938. *Jour. Indian Bot. Soc.* **17**, p. 372.

Vegetative cells 85–90μ x 270–300μ, with plane end walls; chromatophores 5; conjugation unknown; reproduction by aplanospores which are compressed-globose, 71–77μ x 60–67μ; median wall thick, brown, and smooth. (Pl. XLI, Fig. 16.)

India, Gorakhpur, U.P., October, 1936.

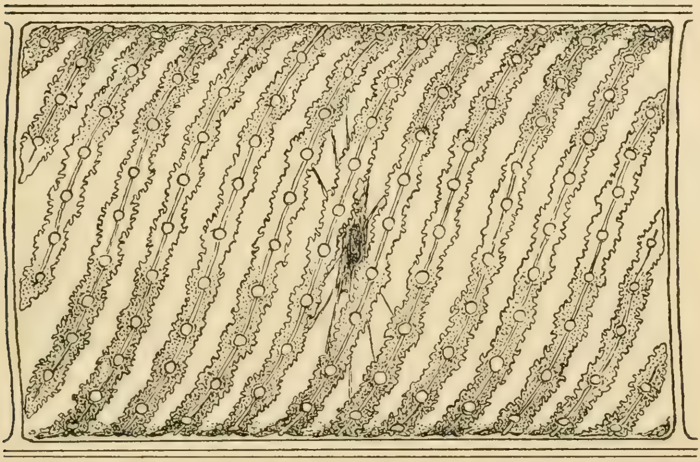


FIG. F.—Vegetative cell of *Spirogyra crassa.* The average length is usually about the same as the diameter, and conjugating filaments always have some cells about one-half the diameter. This cell has 8 chromatophores.

167. SPIROGYRA CRASSA Kützing 1843. *Phycologia Generalis,* p. 280, Pl. 14, Fig. 4.

Vegetative cells 140–165μ x 126–330μ, with plane end walls; 6–12 chromatophores, making .5 to 1 turn; conjugation scalariform; tubes zygospores compressed-ovoid, 120–150μ x 140–160μ x 80–100μ; median spore wall brown, with irregular shallow pits. (Pl. XXXII, Fig. 6.)

United States: Generally distributed, but not common, from Minnesota and Wisconsin to Louisiana and the eastern seaboard.

Europe; Australia; South Africa.

Collections of what appear to be vegetative filaments of this species in shaded ponds are not infrequent, but fruiting specimens are relatively rare.

Most of the early records were based on vegetative filaments. Found hybridizing with *S. nitida* at Starkville, Mississippi. Found conjugating with *S. communis* by Andrews, 1911.

168. Spirogyra manoramae Randhawa 1938. *Proc. Indian Acad. Sci.* **8**, p. 360.

Vegetative cells 80–90μ x 80–160μ, with plane end walls; 7 to 10 chromatophores, straight, or making .5 turn in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells more or less inflated; zygospores lenticular, 75–86μ x 58–80μ; median wall yellow-brown, irregularly corrugate and finely verrucose-punctate. (Pl. XXXII, Fig. 7.)

India, Basti, Upper Punjab.

169. Spirogyra jatobae Transeau 1938. *Amer. Jour. Bot.* **25**, p. 527, Figs. 14–15.

Vegetative cells 118–130μ x 108–500μ, with plane end walls and 8–11 chromatophores, straight or making 1 turn in the cell; conjugation scalariform; tubes formed by both gametangia; receptive gametangia slightly inflated, especially on the conjugating side; zygospores compressed-spherical, 108–140μ x 78–90μ; median wall yellow-brown, irregularly and minutely verrucose. (Pl. XXXII, Figs. 8–9.)

Brazil, Jatoba, October 3, 1933 (Drouet Coll.).

170. Spirogyra maxima (Hassall) Wittrock 1882. *Bot. Notiser.* p. 57.

Vegetative cells 118–140μ x 100–250μ, with plane end walls; 6 to 7 chromatophores, making .2 to .8 turn; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores lenticular, 100–125μ x 75–95μ; median spore wall golden-brown, reticulate. (Pl. XXXII, Figs. 10–11.)

United States: California; Wisconsin; and the eastern half of the United States.

Europe; South America; Australia; India; China.

Found hybridizing with *S. submaxima* (No. 159) at Charleston, Illinois. Wolle collected specimens of *S. maxima* hybridizing with *S. nitida*. These were distributed as No. 541, in Wittrock and Nordstedt's Algae Exsiccatae.

171. Spirogyra heeriana Nägeli 1849. In Kützing, *Species Algarum,* p. 442. *Tabulae phycologicae.* 5, Pl. 28, Fig. 3.

Vegetative cells 130–150μ x 130–250μ, with plane end walls; about 8 chromatophores, making .5 to 1 turn in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells not inflated,

although the tubes become very wide; zygospores lenticular, about 150 μ in diameter; median wall yellow-brown, thick, with round brown papillae irregularly distributed over the surface. (Pl. XXXII, Figs. 12–13.)

Austria, Vienna; France.

172. SPIROGYRA CRASSIUSCULA (W. & N.) Transeau 1934. *Ohio Jour. Sci.* 34, p. 420. Wittrock and Nordstedt Algae Exsiccatae, No. 746.

Vegetative cells 145–170 μ x 140–300 μ, with plane end walls; 6 to 7 chromatophores, making .5 to 1 turn in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores lenticular, 120–150 μ x 85–100 μ; median spore wall yellow-brown, reticulate.

England, Essex; South Africa.

In appearance this and the next species are similar to *S. maxima,* but are larger in all dimensions.

173. SPIROGYRA MEGASPORA (Lagerheim) Transeau 1934. *Ohio Jour. Sci.* 34, p. 420. In Wittrock and Nordstedt Algae Exsiccatae, No. 745.

Vegetative cells 170–200 μ x 150–400 μ, with plane end walls; 6 to 7 chromatophores, making .5 to 1 turn in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores lenticular, 135–170 μ x 90–120 μ; median spore wall yellow-brown, reticulate.

Uruguay; Sweden.

174. SPIROGYRA LENTICULARIS Transeau 1938. *Amer. Jour. Bot.* 25, p. 528, Figs. 18–19.

Vegetative cells 150–162 μ x (80–)125–200(–300) μ, with plane end walls; 9 or 10 chromatophores, straight, or making 1 turn in the cell; conjugation scalariform; tubes formed by both gametangia; receptive gametangia shortened and cylindric or slightly enlarged on the inner side; zygospores compressed-spheroid, 136–145 μ x 90–100 μ; outer wall thin, smooth, transparent; median wall thick, minutely verrucose and with labyrinthine reticulations, brown. (Pl. XXXII, Figs. 14–15.)

South Africa, Cape Town (E. Stephens Coll.).

175. SPIROGYRA CRASSOIDEA Transeau 1937. *Amer. Midland Naturalist.* 18, p. 936, Pl. 5, Fig. 77. *Amer. Jour. Bot.* 1, p. 295, Pl. 27, Fig. 2.

Vegetative cells 140–150 μ x 140–560 μ, with plane end walls; 3 to 8 chromatophores, making .5 to 3 turns in the cell; conjugation scalar-

iform; tubes formed by both gametangia; fertile cells cylindric; zygospores compressed-ellipsoid, 120–140μ x 145–255μ; median spore wall smooth, yellow-brown. (Pl. XXXIII, Fig. 1.)

United States: Iowa; Illinois; Ohio.

Resembles *S. ellipsospora*, but the form of the spores is quite distinctive. It should not be confused with *S. crassa*, as was done by Czurda 1932, page 216, although on page 202 he republished the figures of the "crassoidea" spore (Fig. 217b) as that of *S. ellipsospora*, which further confused the identity of this species. In 1 plane the spore is distinctly ellipsoid, in the plane at right angles the spore is ovoid.

176. Spirogyra rectispira Merriman 1922 [Char. amend]. *Amer. Jour. Bot.* **9**, p. 283.

Vegetative cells 150–180μ x 75–320μ, with plane end walls; 11–16 chromatophores, straight or making .1 to 1 turn; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or enlarged on the inner side; zygospores compressed-ovoid, 140–152μ x 168–185μ x 110–130μ; median spore wall minutely verrucose, brown.

United States: New York City, Van Cortlandt Park.

Original description is incorrect in several particulars. This description is based on the original material kindly sent me by Miss Merriman.

PLANE END WALLS

CONJUGATING TUBES BY MALE GAMETANGIA

177. Spirogyra hydrodictya Transeau 1915. *Ohio Jour. Sci.* **16**, p. 28.

Vegetative cells 75–100μ x 210–360μ, with plane end walls; 7 to 10 chromatophores, straight or making .1 to .5 turn; conjugation scalariform and lateral; tubes formed by the male gametangia; fertile cells shortened and enlarged, or slightly inflated; zygospores lenticular to lenticular-globose, 80–120μ x 110–195μ; median spore wall brown, pitted. (Pl. XXXIII, Figs. 2–4.)

United States: Illinois, Coffeen, Prairie Pond, May 23, 1915. Great masses of the tangled filaments of this species were present on this date, but it was not found there again in subsequent years although it was searched for annually.

178. Spirogyra texensis Taft 1944. *Ohio Jour. Sci.* **44**, p. 238.

Vegetative cells 50–55μ x 90–530μ, with plane end walls; 3 to 5 chromatophores, making 1.5 to 3.5 turns in the cell; conjugation scalariform; tubes formed by the male gametangia; fertile cells shortened and enlarged; zygospores ovoid, 66–76μ x 99–124μ; outer spore wall transparent, irregularly corrugate; median wall yellow-brown, conspicuously reticulate. (Pl. XXXIII, Fig. 5.)

United States: Texas, Karnac, April 27, 1938.

In this collection the outer spore wall was much larger than the median wall.

179. Spirogyra taylorii Jao 1935. *Trans. Amer. Micros. Soc.* **54**, p. 4, Pl. 1, Figs. 2–3.

Vegetative cells 12–16μ x (48–)70–193μ, with plane end walls; 1 chromatophore, making 2.5 to 6 turns in the cell; conjugation scalariform; tubes formed by the male gametangia; fertile cells inflated toward the middle and usually more on the conjugating side, up to 33μ; zygospores ellipsoid, 19–29μ x 39–45μ; median spore wall finely reticulate to punctate, yellowish-brown at maturity. (Pl. XXXIII, Fig. 9.)

United States: Massachusetts, Woods Hole.

The fertile cells are continuous in the filaments, not separated as in the next species. Named for W. R. Taylor, University of Michigan, author of *Marine Algae of the Northeastern Coast of North America* and many contributions to both fresh-water and marine phycology.

180. Spirogyra liana Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 228.

Vegetative cells 11–16μ x 75–160μ, with plane end walls; 1 chromatophore, making 2 to 6 turns; conjugation scalariform and lateral; tubes formed wholly by the male gametangia; inflated single or paired fertile cells usually separated by 1 to 5 nonconjugating cells; zygospores ellipsoid, 23–30μ x 35–50μ; median spore wall yellow, smooth. (Pl. XXXIII, Figs. 10–11.)

China, Szechwan and Kiangsi; Sweden.

Named for Liang Ching Li, Fan Memorial Institute, Peiping, China. This is one of the smallest of the species with plane end walls in which the conjugating tubes are formed by the male gametangia. In most of these species (Nos. 177 to 197), the conjugating cells are arranged singly or in pairs with one to several intervening nonconjugating cells. At the inception of conjugation, food substances accumulate in these gametangia and they become darker green and filled with starch grains. At the same time the intervening cells become lighter green and the chromatophores become thinner and narrower. This group of species may be designated the "punctata group" after the first of these species to be described.

S. hydrodictya (No. 177) has these same characteristics and has in addition the compressed-spherical spores characteristic of the "majuscula group" of species. This species illustrates one of the difficulties in the path of anyone who attempts to subdivide the genus *Spirogyra* on the basis of tube formation or spore form.

Among the replicate species of *Spirogyra* there is a corresponding group

in which the tubes are similarly formed by the male cell, but the segregation of reproductive and vegetative cells is not so evident.

181. SPIROGYRA PRESCOTTII (Prescott) Transeau 1944. *Ohio Jour. Sci.* 44, p. 243. *Amer. Midland Naturalist.* 27, p. 673, Pl. 4, Figs. 15–17. 1942 (as *S. collinsii* var. *minor*).

Vegetative cells 13–14μ x 115–140μ, with plane end walls; 1 chromatophore, loosely spiraled; conjugation scalariform; tubes formed by the male gametangia; fertile cells inflated to 33μ; zygospores ovoid to ellipsoid, 29μ x 39–40μ; median spore wall coarsely punctate, yellow.

United States: Massachusetts, Falmouth, July, 1933.

The dimensions are so much smaller than those of *S. collinsii* that it seems better to separate it as a distinct species, although it is certainly very similar in other respects. Named for G. W. Prescott, State College, Michigan, author of many publications on fresh-water algae including *Algae of Iowa.*

182. SPIROGYRA CHENII Jao 1935. *Sinensia.* 6, p. 587, Pl. 4, Fig. 52.

Vegetative cells 19–22μ x 38–115μ, with plane end walls; 1 chromatophore, making 1 to 5 turns in the cell; conjugation lateral and scalariform; conjugating tubes formed by the male gametangia; fertile cells inflated up to 42μ, usually separated by 1 or more sterile cells; zygospores ellipsoid, 25–32μ x 45–61μ; median spore wall smooth, yellow at maturity. (Pl. XXXIII, Fig. 14.)

China, Szechwan.

183. SPIROGYRA COLLINSII (Lewis) Printz 1927. Engler and Prantl. *Pflazenfamilien.* Second edition, 3, p. 371. *Amer. Jour. Bot.* 12, p. 351, 1925 (as *Temnogyra collinsii*).

Vegetative cells 18–22μ x 100–200μ, with plane end walls; 1 chromatophore, rarely 2 in some cells, making from 3 to 9 turns in the cell; conjugation usually lateral, sometimes scalariform; tubes formed mostly by the male gametangia; fertile cells inflated, 25–39μ x 45–110μ; zygospores ellipsoid, or sometimes ovoid, 26–37μ x 52–62(–110)μ; median spore wall coarsely punctate, yellow. (Pl. XXXIII, Figs. 12–13.)

United States: Massachusetts, Woods Hole, July, 1922; Mississippi, Biloxi, February 14, 1934 (Hicks Coll.); Florida, Daytona, March 12, 1931 (Tiffany Coll.), and Tarpon Springs, August 7, 1945 (R. K. Salisbury Coll.).

This species is one of the most specialized of the "punctata group" in that the gametangia are much smaller than the vegetative cells, and most of the chromatophore passes into the gametangial end during cell division, leaving only a small portion in the sterile cell. This remnant is often flat and straight, or only slightly curved, as in *Mougeotia.* When I first saw the species in the Biloxi collections I took it to be a *Temnogametum* until I

found the earlier stages of conjugation. It is therefore easy to understand why Professor Ivey Lewis proposed a new genus for this species and gave it the name *Temnogyra.* The species is named in honor of Frank S. Collins of Malden, Massachusetts, who published *The Green Algae of North America* in 1909 and numerous other papers on fresh-water and marine algae.

184. Spirogyra punctata Cleve 1868. *Nova Acta Reg. Soc. Sci. Upsali.* Ser. 3, **6**, p. 23, Pl. 4, Figs. 1–4.

Vegetative cells 24–30μ x 70–360μ, with plane end walls; 1 chromatophore, making 3 to 8 turns in the cell; conjugation lateral and scalariform; tubes formed by the male gametangia; gametangia single, or in pairs, separated by much longer sterile cells in each filament; fertile gametangia inflated to 45μ; zygospores ellipsoid, 28–43μ x 42–78μ; median spore wall coarsely punctate, yellow. (Pl. XXXIV, Fig. 1.)

United States: Iowa to Massachusetts and New Jersey.

Reported from Europe, Afghanistan, China, and Australia.

Some of the older records would now be changed to other species of the "punctata group" since they were probably made on the basis of the tubes and of the contrast between gametangia and sterile cells. The species described by Jao as *S. collinsii* var. *ampla* (*Trans. Amer. Micros. Soc.,* **54**, p. 2. 1935) seems to belong here, and I have used his drawing to illustrate this species.

185. Spirogyra sirogonioides Hughes 1943. *Abstracts of Doctoral Dissertations.* The Ohio State University, 40, 1943.

Vegetative cells 17–22μ x (60–)160–220μ with plane end walls; 1 chromatophore, making 3 to 6 turns in the cell; conjugation lateral and scalariform; tubes formed mostly by the male gametangia, sometimes becoming very broad at maturity; receptive gametangia inflated on the conjugating side; zygospores ellipsoid, 35–39μ x 58–67μ; median wall yellow-brown, ornamented with variably shaped and irregularly distributed scrobiculae. (Pl. XXXIII, Figs. 7–8.)

Canada, Charleston, Queens County, Nova Scotia, July, 1941, and 1942.

The specific name was suggested by the fact that occasional mature pairs of gametangia have the appearance of conjugated cells in *Sirogonium.*

186. Spirogyra lushanensis Li 1938. *Bull. Fan Mem. Inst. Biol.* **8**, p. 92, Pl. 2, Figs. 4–5.

Vegetative cells 17–23μ x 84–158μ, with plane end walls; 1 chromatophore, making 3.5 to 7 turns in the cell; conjugation scalariform; tubes formed wholly by the male gametangia; fertile cells inflated to 38μ and shortened; zygospores ellipsoid, 26–36μ x 42–78μ; median wall irregularly reticulate, yellow. (Pl. XXXIII, Fig. 6.)

China, Kiangsi, Lushan, September, 1936.

187. Spirogyra esthonica (Skuja) Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 180, Fig. 191. *Acta Horti Bot. Univ. Latviensis.* **3**, p. 109 (as *S. punctata* var. *esthonica*).

Vegetative cells 27–33μ x 90–360μ, with plane end walls; 1 chromatophore, making 3 to 9 turns in the cell; conjugation scalariform; tubes formed largely by the male gametangia; receptive gametangia inflated up to 60μ; gametangia usually separated by sterile cells; zygospores ellipsoid, 39–50μ x 64–115μ; median wall irregularly corrugate with minute punctations between the ridges. (Pl. XXXIV, Figs. 2–3.)

Estonia, July, 1927.

188. Spirogyra suomiana Transeau 1934. *Ohio Jour. Sci.* **34**, p. 420. Hirn, Karl E. *Acta Soc. pro Fauna et Flora Fennica.* **11** (10), p. 10, Pl. 1, Fig. 3. 1895.

Vegetative cells 33–40μ x 100–240μ, with plane end walls; 1 chromatophore, making several turns in the cell; conjugation scalariform; tubes formed by the male gametangia; receptive gametangia inflated to 58–73μ; gametangia separated by much longer sterile cells; zygospores ovoid, 45–53μ x 75–90μ; median wall golden yellow, coarsely punctate. (Pl. XXXIV, Fig. 4.)

Finnish Lapland; China, Tsingtao (Li Coll.); Manchuria.

189. Spirogyra punctiformis Transeau 1914. *Amer. Jour. Bot.* **1**, p. 294.

Vegetative cells 27–30μ x 120–390μ, with plane end walls; 1 or 2 chromatophores, making 3 to 6 turns; conjugation scalariform; conjugating tubes usually produced by the male gametangia; fertile cells in pairs or singly between vegetative cells, inflated to 45–50μ; zygospores ovoid, 40–48μ x 60–110μ; median spore wall yellow, punctate. (Pl. XXXIV, Figs. 5–6.)

United States: Iowa; Illinois.

190. Spirogyra reflexa Transeau 1915. *Ohio Jour. Sci.* **16**, p. 28.

Vegetative cells 30–44μ x 120–300μ, with plane end walls; 1 chromatophore, making 3 to 8 turns; conjugation scalariform; tubes formed by the male gametangia; fertile cells inflated or enlarged and strongly reflexed, single or in groups of 2 or 4; zygospores and aplanospores ellipsoid, 44–64μ x 90–150μ; median spore wall yellow-brown, smooth. (Pl. XXXIV, Figs. 7–8.)

United States: Illinois; Michigan; Indiana; Mississippi.

191. Spirogyra micropunctata Transeau 1915. *Ohio Jour. Sci.* **16**, p. 27.

Vegetative cells 30–36μ x 120–300μ, with plane end walls; 1 chro-

matophore, making 3 to 7 turns; conjugation scalariform; conjugating tubes formed almost wholly by the male gametangia; fertile cells in groups of 2 or 4, rarely continuous, inflated on the inner side to 50 μ; zygospores ellipsoid, 37–42 μ x 57–100 μ; median spore wall yellow, minutely punctate. (Pl. XXXIV, Fig. 9.)

United States: Wisconsin (Prescott Coll.); Illinois; Arkansas (Couch Coll.).

192. Spirogyra corrugata Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 229.

Vegetative cells (30–)32–36(–40) μ x 140–280(–400) μ, with plane end walls; 1 to 3 chromatophores, making 2 to 4 turns; conjugation scalariform; tubes formed by the male gametangia, usually long and broad; fertile cells solitary or in pairs (rarely in series) between vegetative cells, shortened and inflated to 40–60 μ; zygospores ovoid, 42–60 μ x 80–120 μ; median spore wall of 2 layers, outer thin, coarsely and irregularly corrugate; inner yellow or brownish-yellow, finely reticulate. (Pl. XXXIV, Figs. 10–11.)

United States: Illinois; Mississippi; Alabama (Thut Coll.); Tennessee (Bold Coll.); Oklahoma (Taft Coll.); West Virginia (Hamblin Coll.).

China, Szechwan (Jao Coll.).

193. Spirogyra rugulosa Ivanof 1902. From *Bot. Zentralbl.* **93**, p. 383. 1903. Teodoresco. *Bot. Zent. Beih.* **21**, p. 192, Figs. 81–87. 1907.

Vegetative cells 47–57 μ x 100–350 μ, with plane end walls; 1 chromatophore, making 3 to 11 turns; conjugation scalariform; tubes formed by male gametangia; fertile cells shortened, inflated on the conjugating side; zygospores ellipsoid or ovoid, 45–52 μ x 102–127 μ; median spore wall yellow-brown, finely punctate. (Pl. XXXIV, Fig. 14.)

United States: Illinois, Charleston, in an old prairie pond.

Russia, Bologoe; Rumania, Chita.

194. Spirogyra wabashensis Tiffany 1927. *Bot. Gaz.* **83**, p. 202, Pl. 9, Fig. 1.

Vegetative cells 40–50 μ x 120–400 μ, with plane end walls; 2 to 4 chromatophores, making .5 to 4.5 turns; conjugation scalariform; tubes formed by the male gametangia; fertile cells inflated, single or in groups of 2, alternating with vegetative cells; zygospores ellipsoid, 56–76 μ x 110–150 μ; median spore wall yellow, areolate. (Pl. XXXIV, Fig. 13.)

United States: Illinois, Brownsville.

195. Spirogyra conspicua Gay 1884. *Essai d'une monographie locale des Conjuguées,* p. 91, Pl. 4, Fig. 5.

Vegetative cells about 45μ x $45-135\mu$, with plane end walls; 5 chromatophores, making .5 to 1.5 turns; conjugation scalariform; tubes formed by the male gametangia; fertile cells inflated; zygospores ovoid, about 55μ x 82μ; median spore wall brown, smooth.

France, Montpellier.

196. SPIROGYRA VISENDA Transeau 1944. *Ohio Jour. Sci.* **44**, p. 243.

Vegetative cells $40-45\mu$ x $130-300\mu$, with plane end walls; 1 narrow chromatophore, making 4 to 9 turns in the cell; conjugation scalariform, with broad tubes formed wholly by the male gametangia; receptive gametangia inflated to $60-80\mu$; zygospores ellipsoid, sometimes ovoid, $35-65\mu$ x $92-124\mu$; median spore wall yellow, smooth. (Pl. XXXIV, Fig. 15.)

United States: Mississippi, Columbus, April 14, 1935.

Both gametangia are reflexed, and the conjugating pairs are separated by much longer vegetative cells.

197. SPIROGYRA HUNGARICA Langer 1932. *Folia Crypt.* **1**, p. 1070, Figs. 1–8.

Vegetative cells $53-56\mu$ x $150-400\mu$, with plane end walls; 1 chromatophore, making 6 to 10 turns in the cell; conjugation scalariform; tubes obconical, formed wholly by the male gametangia; receptive gametangia slightly inflated on the conjugating side; zygospores ellipsoid, $45-53\mu$ x $120-148\mu$; median spore wall smooth, yellow-brown. (Pl. XXXIV, Fig. 12.)

Hungary, Sopron.

SPECIES WITH SEMIREPLICATE END WALLS

198. SPIROGYRA NARCISSIANA Transeau 1914. *Amer. Jour. Bot.* **1**, p. 290, Pl. 25, Figs. 4–6.

Vegetative cells $12-14\mu$ x $200-400\mu$, with semireplicate end walls; 1 chromatophore, making 2 to 5 turns; zygospores unknown; sporiferous cells inflated toward the middle up to $25-53\mu$; aplanospores ellipsoid to ovoid, $23-30\mu$ x $50-120\mu$; median spore wall yellow, smooth. (Pl. XXXV, Figs. 1–3.)

United States: Illinois, Charleston (above dam in small stream north of golf links), September, 1912.

The end walls of the cells of this and the next species are unique and under the microscope look like an end view of a partly open transom. It was found in this same stream in September in 2 subsequent years but was not found in any other nearby streams, although many collections were made and analyzed.

199. SPIROGYRA UNDULISEPTA Randhawa 1938. *Proc. Indian Acad. Sci.* 8, p. 352.

Vegetative cells 13–18μ x 96–154μ with semireplicate end walls; 1 chromatophore, making 3 to 5 turns; conjugation scalariform; tubes formed by both gametangia; receptive gametangia inflated in the middle up to 30–42μ; zygospores ellipsoid, 20–30μ x 40–53μ; median spore wall yellow-brown, with an undulate outer surface. (Pl. XXXV, Fig. 4.)

India, Fyzabad, Upper Punjab, February 8, 1937.

SPECIES WITH REPLICATE END WALLS

200. SPIROGYRA TENUISSIMA (Hassall) Kützing 1849. *Species Algarum,* p. 437.

Vegetative cells 8–13μ x 40–250μ, with replicate end walls; 1 chromatophore, making 3 to 6 turns; conjugation lateral and scalariform; tubes formed by both cells; fertile cells greatly inflated or enlarged toward the middle; zygospores and aplanospores ellipsoid, 25–32μ x 40–70μ; median spore wall yellow, smooth. (Pl. XXXV, Figs. 5–6.)

United States: Abundant in the eastern half in early spring.

Canada; Europe; Asia; South America; Africa; Australia; New Zealand.

Highly variable in dimensions within the above limits, also in the angles formed by laterally conjugating cells. Several species and varieties have been described which are not listed here. If these variants are recognized, many more can be separated on equally good grounds. The same statement holds for the next species, *S. inflata.*

Found hybridizing with *S. weberi* at Belding, Michigan. Spores in cells of *S. weberi* filaments were ovoid, in the *S. tenuissima* filaments, ellipsoid.

201. SPIROGYRA INFLATA (Vaucher) Kützing 1843. *Phycologia Generalis,* p. 279.

Vegetative cells 15–20μ x 45–230μ, with replicate end walls; 1 chromatophore, making 2.5 to 6 turns; conjugation lateral and scalariform; tubes formed by both gametangia; fertile cells inflated to 35–48μ; zygospores and aplanospores ellipsoid, 27–36μ x 50–76μ; median spore wall yellow, smooth. (Pl. XXXV, Figs. 7–8.)

United States: From Minnesota and Louisiana eastward to the Atlantic coast.

Southern and eastern Canada; Europe; Asia; Africa.

202. SPIROGYRA CYLINDRICA Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 150.

Vegetative cells 13–16μ x 140–350μ, with replicate end walls; 1 chromatophore, making 2.5 to 6 turns in the cell; conjugation lateral

and scalariform; tubes formed almost wholly by the male gametangia; fertile cells inflated toward the center to 29–42μ; zygospores ellipsoid, 22–32μ x 50–71μ; median spore wall yellow-brown, smooth. (Pl. XXXV, Figs. 9–10.)

Austria; Czechoslovakia; China, Szechwan; South Africa.

Neither the description nor the figure of *S. austriaca* Czurda 1932 clearly separates it from this species.

203. Spirogyra pseudospreeiana Jao 1935. *Sinensia.* **6**, p. 608.

Vegetative cells 16–19μ x 140–210μ, with replicate end walls; 1 chromatophore, making 2.5 to 8 turns in the cell; conjugation scalariform; tubes formed by the male gametangia; fertile cells inflated toward the middle up to 39μ, especially on the conjugating side; zygospores ellipsoid, 27–35μ x 45–64μ; median spore wall yellow-brown, smooth. (Pl. XXXV, Fig. 11.)

China, Szechwan, December, 1933.

204. Spirogyra pascheriana Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 150.

Vegetative cells 18–21μ x 120–170μ, with replicate end walls; 1 chromatophore; conjugation lateral and scalariform; tubes formed mostly by the male gametangia; fertile cells more or less cylindrically inflated, up to 60μ; zygospores ellipsoid, 45–50μ x 80–95μ; median wall yellow-brown, smooth, with distinct suture. (Pl. XXXV, Figs. 12–13.)

United States: Minnesota, Grand Marais (Nichols Coll.), June, 1936.

Czechoslovakia, Prague.

205. Spirogyra hopeiensis Jao 1935. *Sinensia.* **6**, p. 608.

Vegetative cells 26–29μ x 154–400μ, with replicate end walls; 1 chromatophore, making 2 to 6 turns in the cell; conjugation scalariform; tubes formed by the male gametangia; fertile cells inflated on the conjugating side up to 55μ; zygospores ellipsoid, 32–48μ x 61–96μ; median spore wall smooth, yellow. (Pl. XXXV, Fig. 17.)

China, Hopei and Szechwan; in the former province in June, in the latter in December.

206. Spirogyra farlowii Transeau 1915. *Ohio Jour. Sci.* **16**, p. 29. Phycoth. Bor.-Amer., No. 362.

Vegetative cells 24–30μ x 70–400μ, with replicate end walls; 1 chromatophore, making 2.5 to 6 turns; conjugation scalariform and lateral; tubes formed by both cells; fertile cells inflated to 39–60μ; zygospores and aplanospores ellipsoid, ends more or less pointed, 32–45μ x 48–96μ; median spore wall yellow, smooth. (Pl. I, Fig. 3.)

United States: Iowa; Michigan; Kentucky; Indiana; Ohio; New Hampshire; Massachusetts.

China, several provinces (Li Coll. and Jao Coll.).

Named for W. G. Farlow, Harvard University, founder of the Farlow Herbarium and Library.

207. Spirogyra weberi Kützing 1843. *Phycologia Generalis,* p. 279.

Vegetative cells 19–30μ x 80–480μ, with replicate end walls; 1 chromatophore, making 3 to 6.5 turns; fertile cells usually slightly enlarged; conjugation scalariform; tubes formed by both cells; zygospores ovoid to cylindric-ovoid, 21–30μ x 30–96μ; median spore wall yellow, smooth; aplanospores similar. (Pl. XXXV, Fig. 14.)

United States: Generally distributed in the eastern half, but not common; also in Colorado.

Widely distributed in Europe, China, Java.

Found hybridizing with *S. tenuissima* at Belding, Michigan (Ackley Coll.).

208. Spirogyra semiornata Jao 1935. *Sinensia.* 6, p. 604, Pl. 9, Figs. 97–98.

Vegetative cells 27–32μ x 96–245μ, with replicate end walls; 1 chromatophore, making 2 to 6 turns in the cell; reproduction usually by zygospores, rarely by aplanospores; conjugation lateral and scalariform; tubes formed by both gametangia; fertile cells enlarged; zygospores ovoid, 35–46μ x 61–106μ; aplanospores subglobose to ovoid, 32–38μ x 35–51μ; median spore wall yellow-brown, smooth. (Pl. XXXV, Figs. 15–16.)

China, Szechwan, November to January.

209. Spirogyra nyctigama Transeau 1938. *Amer. Jour. Bot.* 25, p. 525, Fig. 11.

Vegetative cells 34–38μ x 72–180μ, with replicate end walls; 1 chromatophore, making 2 to 5 turns; conjugation scalariform; tubes formed by both gametangia; receptive gametangia inflated to 65μ; zygospores ellipsoid, 47–54μ x 80–98μ; median wall yellow-brown, smooth. (Pl. XXXV, Fig. 18.)

South Africa, Cape Town (Stephens Coll.).

210. Spirogyra grevilleana (Hassall) Kützing 1849. *Species Algarum,* p. 438.

Vegetative cells 22–33μ x 60–325μ, with replicate end walls; 1 chromatophore, in some cells 2, making 4 to 9 turns; conjugation scalariform and lateral; tubes formed largely by the male gametangia; fertile cells fusiform-inflated to 36–43μ; zygospores ovoid, 30–37μ x 60–90μ; median spore wall yellow, smooth. (Pl. XXXV, Figs. 19–20.)

United States: Iowa and Missouri eastward to New Jersey.

Europe; Australia; China.

This includes the variant described by Czurda (1930) as *S. grevilleana* (Hassall) Czurda.

211. Spirogyra chuniae Jao 1935. *Sinensia.* **6**, p. 609, Pl. 10, Fig. 105.

Vegetative cells 28–39μ x 67–130μ, with replicate end walls; 1 chromatophore, in some cells 2, making 2 to 5.5 turns in the cell; fertile cells inflated; reaching a diameter of 80μ; conjugation scalariform; tubes very short, sometimes formed only by the male gametangia; zygospores ellipsoid with pointed ends, 35–43μ x 70–119μ; median spore wall yellow, smooth. (Pl. XXXVI, Fig. 1.)

China, Chungking.

212. Spirogyra incrassata Czurda 1930. *Beih. Bot. Zentralbl.* **47**, p. 38, Fig. 10.

Vegetative cells 26–30μ x 200–250μ, with replicate end walls; (1–) 2 chromatophores; conjugation lateral and scalariform; tubes formed by both cells; fertile cells greatly inflated toward the middle; zygospores ellipsoid, 42–52μ x 110μ; median spore wall yellow-brown, irregularly punctate, and inwardly channeled. (Pl. XXXVI, Figs. 2–4.)

Germany, Berlin.

213. Spirogyra rugosa (Transeau) Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 156. *Amer. Jour. Bot.* **1**, p. 291. 1914. Phycoth. Bor.-Amer., No. 456 (as *S. tenuissima* var. *rugosa*).

Vegetative cells 10–13μ x 50–210μ, with replicate end walls; 1 chromatophore, making 2 to 6 turns; conjugation lateral and scalariform; tubes formed by both gametangia; fertile cells greatly inflated toward the middle; zygospores ellipsoid, 28–32μ x 55–66μ; median spore wall yellow-brown, minutely scrobiculate.

United States: Iowa; Illinois; Massachusetts; Rhode Island; New Jersey.

214. Spirogyra foveolata (Skuja) Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 157. Skuja. *Acta Horti Bot. Univ. Latviensis.* **3**, p. 107. 1928. Not *S. inflata* var. *foveolata* Transeau 1914 (see No. 216).

Vegetative cells 11–16μ x 90–250μ, with replicate end walls; 1 chromatophore, making 3 to 10 turns in the cell; conjugation usually lateral, sometimes scalariform, with the tubes formed mostly by the male gametangia; fertile gametangia inflated to 30–45μ toward the middle; zygo-

spores ellipsoid, 20–31 μ x 43–92 μ; median spore wall reticulate, yellow-brown. (Pl. XXXVI, Fig. 5.)

United States: Arkansas (G. C. Couch Coll.); Minnesota near Grand Marais (Nichols Coll.).

Latvia; China, Szechwan (Jao Coll.); India (Randhawa Coll.).

Perhaps *S. tandae* Randhawa should be included here, though slightly larger than the type.

215. Spirogyra kuusamoensis Hirn 1895. *Acta Soc. pro Fauna et Flora Fennica.* **11**, p. 11, Fig. 4.

Vegetative cells 13–17 μ x 90–135 μ, with replicate end walls; 1 chromatophore; conjugation lateral and scalariform; tubes formed by both gametangia; fertile cells greatly enlarged toward the middle; zygospores ellipsoid, 23–33 μ x 45–75 μ; median spore wall yellow, finely punctate. (Pl. XXXVI, Fig. 7.)

Finland; India, Bombay.

216. Spirogyra discreta Transeau 1934. *Ohio Jour. Sci.* **34**, p. 420. *Amer. Jour. Bot.* **1**, p. 291. 1914 (as *S. inflata* var. *foveolata*).

Vegetative cells 16–20 μ x 50–220 μ, with replicate end walls; 1 chromatophore, making 3 to 6 turns in the cell; conjugation lateral and scalariform; tubes formed by both gametangia; fertile cells greatly inflated toward the middle; zygospores ellipsoid, 28–36 μ x 50–75 μ; median spore wall scrobiculate, yellow. (Pl. XXXVI, Fig. 6.)

United States: Illinois, Casey and Charleston.

China (Li Coll.).

217. Spirogyra amplectens Skuja 1937. *Symbolae Sinicae.* **1**, p. 85, Figs. 9–11.

Vegetative cells 15–20 μ x 60–200 μ, with replicate end walls; 1 chromatophore; conjugation lateral; receptive gametangia cylindrically inflated to 30–50 μ; zygospores ellipsoid, 32–40 μ x 53–73 μ; outer spore wall thick, hyaline, inwardly scrobiculate-punctate; median wall thick, yellow-brown, outwardly reticulate, inwardly scrobiculate-punctate; inner wall thin, hyaline and externally rugose. (Pl. XXXVI, Figs. 8–9.)

China, Yungning, Tschescha Pass, altitude 12,000 feet, July 25, 1915.

This species is very near *S. discreta* but differs in the cylindrically inflated fertile cells and the elaborately ornamented spore walls.

218. Spirogyra groenlandica Rosenvinge 1883. *Öfvers. Kgl. Vet.-Akad. Förhandl.* Stockholm, 1883, No. 8, p. 37, Pl. 8, Figs. 1–11.

Vegetative cells 18–24 μ x 360–600 μ, with replicate end walls; 1

chromatophore, making 3 to 8 turns in the cell; reproduction by zygospores and aplanospores; conjugation lateral and scalariform; tubes formed by both gametangia; receptive gametangia more or less cylindrically inflated up to 51 μ toward the middle; zygospores ellipsoid to cylindric-ellipsoid, 34–48 μ x 100–130 μ; median wall smooth, chestnut brown; aplanospores similar, 34–44 μ x 60–90 μ. (Pl. XXXVI, Figs. 10–13.)

United States: Several localities near Boston, Massachusetts (Bullard Coll.); Illinois, Coles County near Lerna.

Original collection from Disko, Greenland, August 7, 1871, by T. M. Fries. Identity of American material verified by Rosenvinge. Cell walls of this species are unusually light-refractive and appear brighter and better defined than those of other species of the genus—probably due to a larger proportion of cellulose in the walls.

219. Spirogyra quadrata (Hassall) Petit 1874. *Bull. soc. bot. de France.* **21**, p. 41, Pl. 1, Fig. 2.

Vegetative cells 24–30 μ x 70–300 μ, with replicate end walls; 1 chromatophore, making 1.5 to 6 turns in the cell; reproduction by zygospores and aplanospores; conjugation scalariform and lateral; tubes formed by both gametangia; receptive gametangia cylindrically inflated toward the middle up to 60 μ; zygospores ellipsoid to cylindric-ellipsoid, 33–44 μ x 50–82 μ; median wall smooth, brown; aplanospores similar but smaller. (Pl. XXXVI, Figs. 14–16.)

United States: All states from Iowa to Massachusetts.

Widely distributed in Europe, and in northern and southern China.

The form with 2 chromatophores in most cells (var. *bifasciata* Kirchner 1878) has been found in Illinois, also in Clark County, Kentucky (McInteer Coll.).

220. Spirogyra fritschiana Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 156. *Trans. Roy. Soc. S. Africa.* **18**, p. 50, Fig. 14A–B (as *S. protecta* var. *inflata*).

Vegetative cells 17–24 μ x 80–260 μ, with replicate end walls; 1 chromatophore; conjugation lateral and scalariform; tubes formed by both gametangia; fertile cells inflated toward the middle; zygospores ellipsoid, 35–40 μ x 55–64 μ; median spore wall brown, coarsely punctate. (Pl. XXXVI, Figs. 19–20.)

South Africa, Kimberley.

221. Spirogyra goetzei Schmidle 1902. Engler's *Bot. Jahrb.* **30**, p. 251, Pl. 4, Fig. 8.

Vegetative cells 22–25 μ x 160–320 μ, with replicate end walls; 1 chromatophore, making 4 to 9 turns in the cell; conjugation scalar-

iform; tubes formed by both gametangia; fertile cells shortened and enlarged to 32μ; zygospores ellipsoid, 28–31μ x 42–62μ; median spore wall punctate to reticulate-punctate, brown. (Pl. XXXVI, Fig. 21.)

United States: Massachusetts, Wellfleet (Bullard Coll.).

Africa, Langenburg, Lake Nyassa.

In the original collection attached and forming long masses in flowing water.

222. Spirogyra dentireticulata Jao 1935. *Sinensia.* **6**, p. 611, Pl. 10, Figs. 114–15.

Vegetative cells 18–26μ x 118–250μ, with replicate end walls; 1 chromatophore, making 2 to 7 turns; conjugation scalariform; tubes formed by both gametangia; zygospores ellipsoid, 29–41μ x 42–80μ; median spore wall reticulate, with minute spines at the intersections of the network, yellow at maturity. (Pl. XXXVI, Figs. 17–18.)

United States: Tennessee, Rutherford County (Bold Coll.).

China, Szechwan, December and January.

223. Spirogyra lambertiana Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 225, Pl. 21, Fig. 60.

Vegetative cells 24–30μ x 120–300μ, with replicate end walls; 1 chromatophore, making 3.5 to 7 turns in the cell; conjugation lateral and scalariform; tubes formed by both gametangia; fertile cells fusiform, inflated to 58–65(–78)μ; zygospores ellipsoid, 34–43μ x 72–90μ; median spore wall of 2 layers; outer, thin, yellow, wrinkled; inner, thick, yellow, or yellow-brown, reticulate. (Pl. XXXVII, Fig. 1.)

United States: Maine; Massachusetts.

India, Fyzabad, February, 1938.

See also Number 262.

224. Spirogyra microgranulata Jao 1935. *Sinensia.* **6**, p. 612, Pl. 10, Figs. 112–13.

Vegetative cells 16–19μ x 154–420μ, with replicate end walls; 1 chromatophore, making 4.5 to 8 turns in the cell, conjugation scalariform; tubes formed by both gametangia; receptive gametangia enlarged; zygospores ovoid, 24–36μ x 51–77μ, with a double colorless outer wall, of which the inner layer is wrinkled; median wall granulate to verrucose, yellow-brown at maturity. (Pl. XXXVII, Figs. 2–3.)

China, Szechwan.

225. Spirogyra laxistrata Jao 1935. *Sinensia.* **6**, p. 611, Pl. 10, Fig. 111.

Vegetative cells 18–20μ x 112–147μ, with replicate end walls; 1 chromatophore, making 2.5 to 4 turns; conjugation scalariform; tubes

formed by the male gametangia; fertile cells cylindrically inflated toward the middle; zygospores ovoid, 35–38μ x 45–48μ; median spore wall double, of which the outer layer is thick, smooth, and yellow; the inner, coarsely areolate, yellow-brown at maturity. (Pl. XXXVII, Fig. 13.)

China, Szechwan, December 27, 1933.

See also Number 262.

226. Spirogyra spreeiana Rabenhorst 1863. *Die Algen Sachsens,* No. 988.

Vegetative cells 18–24μ x 140–600μ, with replicate end walls; 1 chromatophore, making 1.5 to 4 turns; conjugation scalariform and lateral; tubes formed mostly by the male gametangia; fertile cells not shortened, enlarged and inflated toward the middle to 30–42μ; zygospores and aplanospores ellipsoid, 30–36μ x 55–100μ; median spore wall yellow, smooth. (Pl. XXXVII, Figs. 4–6.)

United States: Texas; Iowa; Michigan; Tennessee; eastward to Massachusetts; Washington.

Europe, Germany to Finland and Rumania; South Africa.

Original collection by Th. Spree near Boekhorst, Holland, in 1860. Czurda gives diameter of vegetative cells as 16–18μ, which measurements would exclude the original material.

227. Spirogyra tsingtaoensis Li 1936. *Bull. Fan Mem. Inst. Biol.* 7, p. 61, Pl. 1, Figs. 3–4.

Vegetative cells 20–25μ x 54–80μ, with replicate end walls; 1 chromatophore, making .5 to 2 turns in the cell; conjugation scalariform and lateral; tubes formed by the male gametangia; fertile cells inflated up to 35μ and shortened; zygospores ellipsoid with rounded ends, 24–28μ x 46–52μ; median spore wall smooth, yellow. (Pl. XXXVII, Fig. 7.)

China, Tsingtao, May, 1935.

228. Spirogyra arta Jao 1935. *Sinensia.* 6, p. 602, Pl. 8, Fig. 93.

Vegetative cells 16–18μ x 105–350μ, with replicate end walls; 1 chromatophore, making 3–8 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells enlarged, rarely inflated; zygospores ellipsoid to cylindric-ellipsoid, 22–26(–32)μ x 51–103μ; median spore wall yellow, smooth. (Pl. XXXVII, Fig. 8.)

China, Szechwan, December and January, 1933–34.

229. Spirogyra tumida Jao 1935. *Sinensia.* 6, p. 602, Pl. 9, Fig. 96.

Vegetative cells 16–19μ x 85–175μ, with replicate end walls; 1 chromatophore, making 3 to 9 turns in the cell; conjugation scalariform;

tubes formed by both gametangia; sterile cells more or less cylindrically inflated up to 45μ; fertile cells enlarged; zygospores ellipsoid, 25–35μ x 48–86μ; median spore wall smooth, yellow at maturity. (Pl. XXXVII, Fig. 9.)

China, Szechwan, November to January, 1933–34.

230. Spirogyra croasdaleae Blum 1943. *Amer. Jour. Bot.* **30**, p. 783, Figs. 6–8.

Vegetative cells 17–25μ x 120–300μ, with replicate end walls; 1 chromatophore, making 4 to 8 turns in the cell; conjugation scalariform; tubes formed by the male gametangia; fertile cells much inflated on the conjugating side; zygospores ellipsoid, 26–33μ x 46–62μ; median wall yellow, smooth. (Pl. XXXVII, Fig. 14.)

United States: Massachusetts, Naushon Island, July 20, 1942.

231. Spirogyra lamellosa Jao 1935. *Sinensia.* **6**, p. 605, Pl. 9, Fig. 99.

Vegetative cells 29–32μ x 188–280μ, with replicate end walls; 1 chromatophore, making 4 to 6 turns in the cell; conjugation scalariform; tubes narrow and long (32–96μ), formed by both gametangia; fertile cells cylindric or enlarged; zygospores ellipsoid to cylindric-ellipsoid, 32–42μ x 80–102μ; outer wall colorless, lamellate, 3–4μ in thickness; median wall smooth, yellow at maturity. (Pl. XXXVII, Fig. 16.)

China, Szechwan, December, 1933.

The conjugating tubes are similar to those of Numbers 243, 245, and 264.

232. Spirogyra laxa Kützing 1849. *Species Algarum,* p. 438. *Tabulae phycologicae.* **5**, Pl. 30, Fig. 5.

Vegetative cells 30–36μ x 120–320μ, with replicate end walls; 1 chromatophore, making 3 to 5 turns; conjugation lateral and scalariform; tubes formed by both gametangia; fertile cells cylindric; zygospores ellipsoid, with more or less pointed ends, 30–33μ x 60–82μ; median spore wall yellow, smooth.

United States: Iowa; Michigan; Indiana.

Nova Scotia (Hughes Coll.); Europe.

233. Spirogyra tjibodensis Faber 1912. *Ann. Jard. Bot. Buitenzorg.* **26**, p. 265.

Vegetative cells 45–50μ x 80–130μ, with replicate end walls; 1 chromatophore, making about 4 turns; reproduction by zygospores and aplanospores; conjugation scalariform; tubes formed by both gam-

etangia; fertile cells cylindric; zygospores ellipsoid, 32–35μ x 37–42μ; median wall brown; aplanospores, 30–34μ x 35–40μ, similar.

Java, Tjibodas.

234. Spirogyra articulata Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 226, Pl. 22, Figs. 67–69.

Vegetative cells 24–28μ x 360–600μ, with replicate end walls; 1 chromatophore, making 3 to 8 turns in the cell; zygospores unknown; reproducing by ellipsoid aplanospores, 36–40μ x 60–88μ; median spore wall yellow, smooth; sporangia cylindric, enlarged or slightly inflated, sometimes straight, often bowed or bent toward the middle. (Pl. XXXVII, Fig. 10.)

United States: Mississippi, Columbus; Indiana, Vigo County (Ben Smith Coll.).

235. Spirogyra latviensis (Skuja) Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 147. Skuja. *Acta Horti Bot. Univ. Latviensis.* **3**, p. 109. 1928 (as *S. protecta* forma). Also described as *S. petitiana* Transeau 1934.

Vegetative cells 20–25μ x 100–250μ, with replicate end walls; 1 chromatophore, making 3 to 5.5 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated to 30–40μ; zygospores ovoid to cylindric-ovoid, 29–39μ x 75–115μ; *outer* hyaline spore wall of 2 layers, of which the outer is thin; the inner, thick, verrucose, with short, pointed elevations; median wall smooth, yellow-brown.

United States: Minnesota; New York (Blum Coll.); Massachusetts (Bullard Coll.).

Latvia.

236. Spirogyra venusta Jao 1935. *Sinensia.* **6**, p. 614, Pl. 10, Figs. 118–19.

Vegetative cells 25–27μ x 175–350μ, with replicate end walls; 1 chromatophore, making 3 to 6 turns in the cell; conjugation scalariform; tubes formed by both gametangia; sterile cells inflated at the ends; fertile cells cylindric or enlarged; zygospores cylindric-ellipsoid, 26–32μ x 67–84μ; outer spore wall of 2 layers, of which the inner is colorless, strongly scrobiculate; median spore wall smooth and yellow. (Pl. XXXVII, Figs. 17–18.)

China, Szechwan, December 27, 1934.

237. Spirogyra protecta Wood 1872. *Smithson. Contribu. Knowledge.* **19**, p. 165, Pl. 14, Fig. 3. Cleve. *Nova Acta Reg. Soc. Sci. Upsali.* Ser. 3, **6**, p. 26. 1868 (as *S. calospora*

forma *gracilior*). Czurda. *Süsswasserflora Mitteleuropa.* 9, p. 147 (as *S. calospora* Cleve).

Vegetative cells 28–34 μ x 120–425 μ, with replicate end walls; 1, rarely 2, chromatophores, making 2 to 6 turns; reproduction by zygospores and aplanospores; conjugation scalariform; tubes formed by both gametangia; receptive gametangia cylindric or enlarged; zygospores ovoid, 30–38 μ x 66–90 μ; outer spore wall of 2 layers, of which the inner is thick, scrobiculate; median spore wall yellow, smooth; aplanospores similar but smaller. (Pl. XXXVII, Fig. 19.)

United States: Common throughout the eastern half.

Europe, recorded from France to Finland and the Ukraine.

Bessey in 1884 reported conjugation between *S. protecta* and *S. majuscula* in both directions. Spore forms corresponded to those of the female filament. Under the name *S. calospora* Cleve described 2 different forms; the first, and larger, had 1 to 3 chromatophores and a yellow, scrobiculate median spore wall. Wood published an accurate description in 1872.

238. Spirogyra cleveana Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 226. Jao. *Sinensia.* **6**, p. 614, Pl. 11, Fig. 120.

Vegetative cells 34–40 μ x 140–465 μ, with replicate end walls; 1, rarely 2, chromatophores, making 3 to 6 turns in the cell; conjugation scalariform; tubes formed by both gametangia; sterile cells often greatly inflated; fertile cells cylindric or enlarged; zygospores ovoid to cylindric-ovoid, 34–50 μ x 70–125 μ; outer spore wall hyaline, of 2 layers, of which the inner is thick and coarsely scrobiculate; median spore wall smooth, yellow. (Pl. XXXVIII, Fig. 1.)

United States: Common in the eastern half.

China, Szechwan; probably includes the larger forms of *S. calospora* (Cleve) in Europe.

239. Spirogyra denticulata Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 226.

Vegetative cells 42–56 μ x 160–400 μ, with replicate end walls; 1, rarely 2, chromatophores, making 3 to 6 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or enlarged; sterile cells sometimes inflated; zygospores ovoid, 45–60 μ x 76–130 μ; outer hyaline spore wall of 2 layers; the outer thin, smooth; the inner, thick, scrobiculate; median spore wall yellow, smooth. (Pl. XXXVII, Fig. 15.)

United States: Mississippi; Illinois; Indiana; Ohio; Massachusetts.

240. Spirogyra areolata Lagerheim 1883. *Öfvers. Kgl. Vet.-Akad. Förhandl.* Stockholm. **40** (2), p. 56, Pl. 1, Figs. 18–20.

Vegetative cells 30–36 μ x 120–600 μ, with replicate end walls; 1 or

2 chromatophores, making 3 to 9 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated up to 67 μ; zygospores ovoid to ovoid-globose, 40–57 μ x 60–103 μ; outer spore wall of 2 layers, of which the inner is hyaline, scrobiculate; median spore wall yellow-brown, smooth. (Pl. XXXVIII, Fig. 2.)

United States: Illinois; Ohio; Maine.

Latvia; Germany.

241. Spirogyra tolosana Comere 1899. *Bull. soc. bot. de France.* **46**, p. 168, Pl. 3, Figs. 1–3.

Vegetative cells 28–30 μ x 225–300 μ, with replicate end walls; 2 chromatophores, making 3.5 to 4 turns; conjugation lateral; fertile cells cylindric or enlarged and shortened; zygospores cylindric-ovoid, with ends more or less truncate when filling the gametangium, 26–29 μ x 95–108 μ; median wall yellow-brown, smooth. (Pl. XXXVIII, Fig. 3.)

United States: Indiana, Clay and Vigo Counties (Ben Smith Coll.).

France, Toulouse.

Approaches *S. hassallii,* differs in having smaller ovoid spores.

242. Spirogyra hassallii (Jenner) Petit 1880. *Les Spirogyres des environs de Paris,* p. 13, Pl. 2, Figs. 6–8.

Vegetative cells 26–33 μ x 100–250 μ, with replicate end walls; 2 chromatophores, making 1.5 to 5 turns; conjugation lateral and scalariform; fertile cells fusiform, inflated to 50 μ; tubes formed by both gametangia; zygospores ellipsoid, 39–48 μ x 58–136 μ; median spore wall yellow, smooth. (Pl. XXXVIII, Fig. 4.)

United States: Colorado; North Dakota; Iowa; Illinois; to the New England states.

Widely distributed in Europe and eastern Asia.

243. Spirogyra hartigii Kützing 1855. *Tabulae phycologicae.* **5**, p. 33.

Vegetative cells about 45 μ x 500–675 μ, with replicate end walls; 2 chromatophores, making 2 turns; conjugation lateral and scalariform; tubes formed by both gametangia, longer than usual; and in lateral conjugation the tube primordia arise 4 to 5 μ from the end walls; receptive gametangia enlarged or slightly inflated at the middle; zygospores ovoid, 45–50 μ x 80–105 μ; median spore wall smooth. (Pl. XXXVIII, Figs. 5–6.)

Germany.

The dimensions of the spores are inferred from the figures published. The other characteristics are so striking that although the description is not complete the alga can be identified when collected. See also Number 245, *S. proavita* Langer, and Number 264, *S. crassispina* Jao.

244. Spirogyra gratiana Transeau 1938. *Amer. Jour. Bot.* 25, p. 528, Figs. 12–13.

Vegetative cells 28–33 μ x 144–400 μ, with replicate end walls; usually 3 chromatophores (rarely in some cells 2 or 4); conjugation lateral and scalariform; tubes formed by both gametangia; receptive gametangia cylindric or enlarged; zygospores ellipsoid, 35–47 μ x 108–223 μ; all walls smooth; median wall yellow; aplanospores infrequent, smaller, 38–40 μ x 47–72 μ. (Pl. XXXVIII, Figs. 8–9.)

United States: Minnesota, Grand Marais, June 17, 1936 (Grace Nichols Coll.).

The filaments are remarkable in that they are almost perfectly straight during and after conjugation.

245. Spirogyra proavita Langer 1913. *Bot. Közlemények.* 12, p. 166.

Vegetative cells 37–40 μ x 330–560 μ, with replicate end walls; 2–3 chromatophores, making 1 to 3.5 turns in the cell; conjugation lateral; tubes arising from primordia several microns away from the end wall, thus forming a distinct tube outside the filament; fertile cells cylindric; zygospores ovoid, 38–40 μ x 82–86 μ; median spore wall smooth, brownish-yellow when mature. (Pl. XXXVIII, Fig. 7.)

Hungary.

This species resembles Number 243, *S. hartigii*, in important particulars and perhaps is a somewhat smaller variant; differs from Number 264, *S. crassispina,* in having ovoid spores.

246. Spirogyra transeauiana Jao 1935. *Sinensia.* 6, p. 610, Pl. 10, Fig. 107.

Vegetative cells 42–61 μ x 160–304 μ, with replicate end walls; 2 to 3 chromatophores, making 2 to 5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric or slightly enlarged on the conjugating side; zygospores ellipsoid with rounded ends, 41–58 μ x 96–183 μ; median spore wall yellow, smooth. (Pl. XXXVIII, Fig. 10.)

China, Szechwan.

247. Spirogyra rectangularis Transeau 1914. *Amer. Jour. Bot.* 1, p. 291, Pl. 25, Figs. 9–11.

Vegetative cells 35–40 μ x 150–320 μ, with replicate end walls; 2 to 4 chromatophores, making 2 to 5 turns; conjugation lateral and scalariform; tubes formed by both gametangia; fertile cells cylindrically inflated to 48–70 μ; zygospores ovoid to cylindric-ovoid, 45–65 μ x 75–120 μ; median spore wall yellow-brown, smooth. (Pl. XXXVIII, Figs. 11–12.)

United States: Illinois, Charleston and Lerna.
Austria, Lunz.

248. Spirogyra insignis (Hassall) Kützing 1849. *Species Algarum*, p. 438.

Vegetative cells 39–42μ x 150–590μ, with replicate end walls; 2 to 4 (usually 3) chromatophores, making .5 to 1.5 turns; conjugation scalariform and lateral; tubes formed by both gametangia; fertile cells shortened and inflated; zygospores ellipsoid, 40–48μ x 60–128μ; median spore wall yellow-brown, smooth. (Pl. XLI, Fig. 17.)

United States: Iowa; Illinois.

Widely reported from Europe; China, Nanking and Szechwan.

249. Spirogyra fallax (Hansgirg) Wille 1900. *Nyt Magaz. f. Naturw.* 38, p. 16. Hansgirg. *Hedwigia.* 27, p. 253. 1888 (as *S. insignis* var. *fallax*).

Vegetative cells 36–45μ x 80–165μ, with replicate end walls; 3 to 4 chromatophores, straight, or making .5 to 1.5 turns in the cell; conjugation scalariform; tubes formed by both cells; fertile cells inflated to 48–75μ; zygospores ellipsoid, 45–60μ x 75–120μ; median spore wall brown, smooth. (Pl. XXXVIII, Fig. 13.)

United States: Massachusetts.

Czechoslovakia. See note under *S. inconstans*, Number 252.

250. Spirogyra wangi Li 1933. *Ohio Jour. Sci.* 33, p. 153, Pl. 1, Figs. 7–8.

Vegetative cells 30–32μ x 150–350μ, with replicate end walls; 2 to 3 chromatophores, making 1.5 to 4.5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated toward the middle, up to 72μ; zygospores ellipsoid, 60–64μ x 112–124μ; median spore wall smooth, yellow. (Pl. XXXVIII, Figs. 14–15.)

China, Hangchow, 1930.

251. Spirogyra acanthophora (Skuja) Czurda 1932. *Süsswasserflora Mitteleuropa.* 9, p. 160. Skuja. *Acta Horti Bot. Univ. Latviensis.* 3, p. 114. 1928 (as *S. willei* var. *acanthophora*).

Vegetative cells 30–38μ x 75–350μ, with replicate end walls; 3 to 4 chromatophores, making .5 to 1.5 turns in the cell; conjugation scalariform; tubes formed by both gametangia; receptive gametangia inflated to 50–70μ; zygospores ellipsoid, 42–60μ x 80–140μ; median wall irregularly spinose-reticulate, yellow-brown. (Pl. XXXVIII, Figs. 16–17.)

Latvia, Kemeri.

This species differs from the next (No. 252) in the more prominent spines on the reticulum of the median spore wall, and in the decreased reflexing of conjugating gametangia.

252. Spirogyra inconstans Collins 1912. *Tufts College Studies.* **3**, p. 73; Phycoth. Bor.-Amer., No. 1768. Wittrock and Nordstedt Algae Exsiccatae, No. 958. 1889.

Vegetative cells 28–40 μ x 70–350 μ, with replicate end walls; (2–)3 to 4 chromatophores, nearly straight, or making .5 to 1.5 turns in the cell; conjugation scalariform or rarely lateral; tubes formed by both gametangia; at the time of tube formation both gametangia become reflexed and usually the conjugation between the same pair of filaments is limited to single, or to 2 adjoining pairs of cells; cross conjugation is not infrequent; receptive gametangia shortened and inflated up to 50–75 μ; zygospores ellipsoid to broadly ellipsoid, 45–70 μ x 75–140 μ; median wall reticulate-aculeate, brown. (Pl. XXXVIII, Figs. 18–20.)

United States: Illinois; Michigan; Indiana; Ohio; Massachusetts; Washington (Bodenberg Coll.).

Europe, from Sweden to Rumania.

At the time of tube formation an outer pectic ring is formed at the junction, and at maturity there is usually an outer and an inner tube wall.

The history of the specific name of this species is a striking example of a scientific "Comedy of Errors." In 1889 Nordstedt described and distributed specimens of this alga, as *S. insignis* (Hassall) Kützing forma. In 1899 Wille attached the name *S. fallax* to it, based on a variety described by Hansgirg as *S. insignis* var. *fallax* which has smooth-walled spores, alleging that Hansgirg had overlooked the ornamented median spore wall. In 1907 Teodoresco found an alga similar to Nordstedt's forma, and named it *S. insignis* var. *Nordstedtii.* In 1912 Collins described the same alga as *S. inconstans.* In 1913 Borge perpetuated Wille's error. In 1915 Transeau called attention to the discrepancy between Hansgirg's figure and description and those of Wille, but, following Borge's key, decided in favor of *S. fallax.* In 1918 Collins changed the name in his key to *S. fallax.* In 1928 Skuja renamed the species *S. willei.* Czurda in 1932 relegated Collins' *S. inconstans* to the discard, and used the name *S. willei.* Collins, however, first described the alga as a species and his specific name is therefore valid.

253. Spirogyra borysthenica Kasanofsky & Smirnoff 1913. *Oesterr. Bot. Zeitschr.* **63**, p. 137, Pl. 3.

Vegetative cells 30–40 μ x 180–450 μ, with replicate end walls; 2 to 4 chromatophores, straight, or making up to 2.5 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated up to 70 μ; zygospores ellipsoid, 52–62 μ x 110–160 μ; median spore wall with spinelike or mammaeform papillae, yellow-brown. (Pl. XXXIX, Figs. 1–3.)

United States: Michigan (Ackley Coll.); Iowa (Tiffany Coll.).

U.S.S.R., Bukovina.

254. Spirogyra nawashini Kasanofsky 1913. *Berichte deutsch. bot. Gesells.* **31**, p. 55, Pl. 3.

Vegetative cells 27–41μ x 170–325μ, with replicate end walls; 2 (rarely 1) chromatophores, with .5 to 1.5 turns; conjugation scalariform; tubes formed by both gametangia; fertile cells fusiform, inflated to 50–55μ; zygospores ellipsoid to cylindric-ellipsoid, 30–49μ x 45–100μ; median spore wall reticulate, yellow-brown.

United States: Indiana (Ben Smith Coll.).

Ukraine, Kiev; China, Nanking (Li Coll.); South Africa (Stephens Coll.).

255. Spirogyra tetrapla Transeau 1938. *Amer. Jour. Bot.* 25, p. 528, Fig. 6.

Vegetative cells 30–40μ x 100–250μ, with replicate end walls; 1 or 2 chromatophores, making 2 to 8 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells inflated, up to 66μ; zygospores ellipsoid, 48–58μ x 68–88μ; median wall of 2 layers, of which the outer is thin and irregularly corrugate; the inner, finely reticulate, yellow. (Pl. XXXIX, Fig. 4.)

United States: Illinois; Indiana; Ohio; Mississippi.

256. Spirogyra reticulata Nordstedt 1880. *Bot. Notiser* 1880. p. 118. Wittrock and Nordstedt Algae Exsiccatae, No. 362.

Vegetative cells 28–42μ x 72–460μ, usually with replicate end walls; 1 to 3 (usually 2) chromatophores, making 2 to 4 turns; conjugation scalariform and lateral; tubes formed by both gametangia; fertile cells enlarged or inflated toward the middle to 48–60μ; zygospores mostly ovoid, 45–61μ x 80–120μ; median spore wall yellow-brown, of 2 layers, of which the outer is thin and wrinkled; the inner reticulate. (Pl. XXXIX, Fig. 5.)

United States: Iowa; Oklahoma; Mississippi; eastward to Maine and south to Florida.

Brazil; Europe; China; India.

This description is amended as to the median spore wall. This wall is double in both specimens from Brazil upon which Nordstedt's description is based and is likewise present in the American, European, and Chinese specimens that I have examined.

257. Spirogyra regularis (Cedercreutz) Krieger 1944. *Rabinhorst's Kryptogamenflora.* 13, p. 464. *Acta Soc. pro Fauna et Flora Fennica.* **55** (2), p. 3. 1924.

Vegetative cells 28–32μ x 110–380μ, with replicate end walls; 2 chromatophores, making 4 to 6 turns in the cell; conjugation scalar-

iform; tubes formed by both gametangia; fertile cells enlarged or inflated; zygospores ovoid, 39–45 μ x 60–90 μ, yellow-brown; median wall reticulate. (Pl. XXXVII, Figs. 11–12.)

Finland.

The description does not state whether the median wall is single or double. It is included here as a species closely related to the preceding and characterized by smaller spores and a definite number of chromatophores.

258. Spirogyra crassivallicularis Jao 1935. *Trans. Amer. Micros. Soc.* 54, p. 2, Pl. 1, Fig. 4.

Vegetative cells 54–58 μ x 168–420 μ; end walls replicate; chromatophores usually 4, rarely 3, making 1.5 to 3.5 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells enlarged, or inflated up to 80 μ; zygospores ovoid, 52–71 μ x 90–144 μ; median wall of 2 layers, of which the outer is thin, wrinkled, and yellow; the inner thick, yellow-brown and reticulate with thick irregularly crenulate ridges. (Pl. XXXIX, Fig. 6.)

United States: Massachusetts, Woods Hole.

259. Spirogyra granulata Jao 1935. *Sinensia.* 6, p. 613, Pl. 11, Figs. 116–17.

Vegetative cells 32–35 μ x 147–280 μ, with replicate end walls; 2 chromatophores, making 2.5 to 6 turns in the cell; conjugation lateral; tubes formed by both gametangia; receptive gametangia enlarged toward the middle; zygospores ovoid to cylindric-ovoid, 45–55 μ x 93–131 μ; median wall double, of which the outer layer is thin and irregularly wrinkled; the inner, granulate and slightly wrinkled, yellowish-brown. (Pl. XXXIX, Figs. 7–8.)

China, Szechwan, December, 1933.

See also Number 261, *S. pseudogranulata* Ley.

260. Spirogyra quinquelaminata Jao 1935. *Sinensia.* 6, p. 615, Pl. 11, Figs. 121–22.

Vegetative cells 41–45 μ x 154–280 μ, with replicate end walls; 2 chromatophores, making 2 to 4 turns in the cell; reproduction by zygospores and aplanospores; conjugation scalariform; tubes formed by both gametangia; fertile cells enlarged toward the middle; sterile cells sometimes inflated up to 70 μ; zygospores ovoid, 51–55 μ x 83–144 μ, with 5 layers in the spore wall; outer spore wall of 2 layers, of which the outer is thin and colorless; the inner up to 3.5 μ in thickness and distinctly lamellate; median spore wall yellow-brown, also of 2 layers, of which the outer is thin and somewhat wrinkled; the inner, coarsely and irregularly reticulate, the ridges being crenulate to dentate; aplanospores

subglobose, 41–48μ x 41–67μ, with similarly marked walls. (Pl. XXXIX, Figs. 10–11.)

China, Szechwan, November 11, 1933.

SPECIES DESCRIPTIONS NOT IN PROPER SEQUENCE

261. Spirogyra pseudogranulata Ley 1944. *Sinensia.* **15**, p. 99.

Vegetative cells 36–40μ x 152–378μ, end walls replicate; chromatophores 2; conjugation lateral; tubes formed by both gametangia; receptive gametangia enlarged or inflated; zygospores ovoid, 46–68μ x 100–140μ; median spore wall of 2 layers; the outer thick, irregularly corrugate; the inner minutely reticulate, yellow-brown. (Pl. XXXIX, Fig. 9.)

China, Tong-Kau, Kwangtung, March 10, 1942.

Should be compared with Number 259, *S. granulata* Jao.

262. Spirogyra jaoi Ley 1944. *Sinensia.* **15**, p. 99.

Vegetative cells 19–22μ x 64–216μ, end walls replicate; 1 chromatophore; conjugation scalariform; tubes formed by both gametangia, receptive gametangia inflated; zygospores ovoid, 28–40μ x 54–90μ; median spore walls of 2 layers; the outer thin and wrinkled; the inner smooth, yellow at maturity. (Pl. XXXIX, Fig. 12.)

China, Tong-Kau, Kwangtung, February 17, 1942.

Belongs near Number 225, *S. laxistrata* Jao, from which it differs in the characteristics of the median spore wall, and in the formation of the conjugating tubes.

263. Spirogyra chekiangensis Jao 1939. *Sinensia.* **10**, p. 152.

Vegetative cells 25–28μ x 100–200μ, with plane end walls; 1 chromatophore, making 1–2 turns in the cell; conjugation scalariform; tubes formed by both gametangia; receptive gametangia enlarged; zygospores ovoid, 45–48μ x 85–88μ; median spore wall of 2 layers, of which the outer is thin, irregularly wrinkled and yellow; the inner coarsely and irregularly reticulate, yellow-brown at maturity. (Pl. XXXIX, Fig. 13.)

China, Wenchow.

Compare with Number 45, *S. obovata* Jao, which has somewhat similar vegetative cells but much larger zygospores, and single-layered median spore wall.

264. Spirogyra crassispina Jao 1939. *Sinensia.* **10**, p. 153.

Vegetative cells 30–35μ x 326–351μ, with replicate end walls; chromatophores 2, making 1 to 3.5 turns in the cell; conjugation lateral and scalariform; tubes formed by both cells; receptive gametangia enlarged;

zygospores ellipsoid or sometimes cylindric-ellipsoid, 42–50μ x 80–137μ; median spore wall of 2 layers, of which the outer is thin, yellow, and wrinkled; the inner coarsely dentate or tuberculate, yellow-brown at maturity. (Pl. XXXIX, Figs. 14–16.)

China, Haimen, May 6, 1937.

Compare with Number 243 and Number 245.

265. Spirogyra peipingensis Jao 1939. *Sinensia.* **10**, p. 155.

Vegetative cells 113–125μ x (82–)105–332μ, with plane end walls; chromatophores 5 or 6, making .5 to 2.5 turns in the cell; conjugation scalariform; tubes formed by both cells; receptive gametangia cylindric and shortened; zygospores lenticular, 100–128μ x 82–100μ; median spore wall smooth, yellow-brown at maturity. (Pl. XXXIX, Fig. 20.)

China, Peiping, December, 1935.

Belongs near Number 159, *S. submaxima* Transeau.

266. Spirogyra sphaerocarpa Jao 1939. *Sinensia.* **10**, p. 156.

Vegetative cells 32–40μ x 87–459μ, with plane end walls; chromatophores 4 or 5, making .5 to 1 turn in the cell; conjugation scalariform; tubes formed by both gametangia; receptive gametangia inflated toward the middle up to 75–87μ; zygospores lenticular, 62–75μ x 37–57μ; median spore wall densely punctate, yellow-brown at maturity. (Pl. XXXIX, Figs. 17–18.)

China, Wenchow, May 13, 1937.

Belongs near Number 161, *S. bellis* (Hassall) Cleve.

267. Spirogyra subpellucida Jao 1939. *Sinensia.* **10**, p. 157.

Vegetative cells 40–45μ x 62–225μ, with plane end walls; chromatophores 4 to 7, making .5 to 1.5 turns in the cell; conjugation scalariform; tubes formed by both gametangia; receptive gametangia inflated on the outer side only (up to 55–75μ); zygospores lenticular, 55–62μ x 40–42μ; median spore wall smooth, yellow-brown at maturity. (Pl. XXXIX, Fig. 19.)

China, Wenchow, May 13, 1937.

Should be near Number 156, *S. pellucida* (Hassall) Kützing.

268. Spirogyra macrospora (Rao) Krieger 1944. *Rabenhorst's Kryptogamenflora.* 13, p. 343.

Vegetative cells 22–25μ x 100–120μ, with plane end walls; 1 chromatophore; conjugation scalariform; receptive gametangia inflated; conjugating tubes formed by both cells; zygospores ellipsoid with narrow ends, 28–33μ x 52–73μ; median spore wall smooth and yellow-brown. (Pl. XLI, Fig. 18.)

Germany, Brandenburg; India, Central Provinces.

269. Spirogyra indica Krieger 1944. *Rabenhorst's Kryptogamenflora.* 13, p. 317.

Vegetative cells 36–42μ x 110–152μ, with plane end walls and 1 chromatophore; conjugating tubes formed by both gametangia; conjugation mostly lateral, less frequently scalariform; receptive gametangia cylindric; zygospores ovoid, 33–38μ x 40–62μ; median spore wall thick, smooth, and brown. (Pl. XLI, Figs. 20–21.)

India, Central Provinces; South America, south Chile.

270. Spirogyra czurdae Misra 1937. *Proc. Indian Acad. Sci.* **5**, p. 115, Fig. 3.

Vegetative cells 26–28μ x 52–78μ, with plane end walls and 1 chromatophore; conjugation scalariform; tubes formed by both gametangia; receptive gametangia shortened and enlarged; zygospores globose, 33–34μ in diameter; median spore wall very thick, brown, and scrobiculate; pits 3–4μ in diameter. (Pl. XLI, Figs. 10–11.)

India, Kashmir.

271. Spirogyra sibirica Skvortzof 1927. *Jour. Bot.* **65**, p. 252, Fig. 1.

Vegetative cells about 17μ broad, with plane end walls and 1 chromatophore; conjugation scalariform; tubes formed by male cells; receptive gametangia inflated slightly on the inner side; many sterile cells bullate; zygospores ellipsoid, 20μ x 32–40μ; median spore wall yellow, scrobiculate. (Pl. XLI, Figs. 8–9.)

Russia, Western Altai Mountains, Zaisan district.

272. Spirogyra atasiana Czurda 1939. *Arch. f. Hydrobiol. Suppl. Bd.* **16**, p. 417, Pl. 1, Fig. 3.

Vegetative cells 44–48μ x 92–161μ, with plane end walls and 1 chromatophore; conjugation scalariform; tubes formed apparently by the male gametangia; receptive gametangia cylindric; zygospores ovoid, 41–45μ x 50–90μ; median spore wall thick, yellow-brown, outer surface granulose.

Sumatra, Danau di Atas.

273. Spirogyra pseudoreticulata Krieger 1944. *Rabenhorst's Kryptogamenflora.* 13, p. 400.

Vegetative cells 20–25μ x 75–170μ, with plane end walls and 2 chromatophores; conjugation lateral and scalariform; tubes formed by both cells; receptive gametangia enlarged; zygospores ellipsoid, 30–33μ x 64–68μ; median spore wall brown, with rather fine, irregular, reticulate ridges. (Pl. XLI, Figs. 13–15.)

Brazil, São Paulo.

274. Spirogyra verrucosa (Rao) Krieger 1944. *Rabenhorst's Kryptogamenflora.* 13, p. 398. *Jour. Indian Bot. Soc.* 17, p. 358, Fig. 3.

Vegetative cells 108–126μ x 144–190μ, with plane end walls and 4–8 chromatophores; conjugation scalariform; tubes formed by both cells; receptive gametangia cylindric; zygospores ellipsoid, 89–100μ x 116–165μ; median wall thick, brown, minutely verrucose, and with coarse meshed reticulate ridges. (Pl. XLI, Fig. 19.)

India, Central Provinces.

275. Spirogyra marchica Krieger 1944. *Rabenhorst's Kryptogamenflora.* 13, p. 459.

Vegetative cells 29–32μ x 150–250μ, with replicate end walls and 2 chromatophores; conjugation lateral and scalariform; tubes formed by both cells; receptive gametangia inflated on both sides; zygospores ovoid to ellipsoid with rounded ends, 46–53μ x 86–170μ; median spore wall brown, coarsely verrucose. (Pl. XLI, Figs. 22–23.)

Germany, Brandenburg.

List of the Species of SPIROGYRA with Number

CHAPTER FOURTEEN

THE GENUS SIROGONIUM KÜTZING 1843

The vegetative cells of the species belonging to this genus resemble those of certain species of *Spirogyra* with plane end walls and several narrow chromatophores. The cell wall, however, differs in the absence of an appreciable external pectose layer. The average length of the cell is two to four times the diameter, though exceptional cells may attain lengths of five to seven diameters. The described species have from two to ten chromatophores, which are either straight or only slightly curved, and comparatively narrow.

Conjugation occurs directly between gametangia, without the formation of conjugating tubes. Apparently the gametangia on coming in contact adhere, and the walls in contact change to pectose and pectic acid. At the edges of the contact disc, a ring of pectose develops outside the walls. At the same time the walls of both gametangia grow, and after bending enlarge to a characteristic form best described by the figures on Plate XL.

The development of the gametangia takes places only from certain vegetative cells scattered singly or in pairs along the filaments. Usually the progametangia divide into two unequal gametangia—one short and one long—and food substances accumulate in them. There may be two divisions resulting in a larger gametangium between two short cells. De Bary stated that the first type of division resulted in female and the latter in male gametes; he called the short cells "sterile." However, the development of gametangia is highly variable in some collections. Apparently progametangia may conjugate without division. Any of the short cells may become male gametangia, and division into three cells before conjugation is far less frequent than division into two unequal cells. As a result of the flexing of the gametangia at the beginning of a conjugation, successive conjugations in a particular filament are each with a different filament. Conjugated filaments thus form a tangled net.

Usually the mature spores are ellipsoid, although ovoid spores occur in most collections. The median wall may be smooth or variously ornamented, and the color varies from pale yellow to brown and black.

Twelve species are here described.

Key to the Species of SIROGONIUM

1. Zygospores with a smooth median wall........................ 2
1. Zygospores with a variously ornamented median wall.......... 4
1. Zygospore lenticular .... 12. *S. phacosporum*
   2. Diameter vegetative cells usually less than 36μ .... 1. *S. tenuius*
   2. Diameter vegetative cells usually between 36 and 56μ....... 3
   2. Diameter vegetative cells about 56–66μ .... 4. *S. floridanum*
3. Diameter zygospores about 10–15μ larger than vegetative cells............ 2. *S. sticticum*
3. Diameter zygospores 20–30μ larger than vegetative cells .... 3. *S. megasporum*
   4. Median wall of zygospore single......................... 5
   4. Median wall of zygospore double... 10. *S. hui*
5. Median spore wall "punctate"......... 6. *S. ceylanicum*
5. Median spore wall finely corrugate and granulose .... 5. *S. pseudofloridanum*
5. Median spore wall brown to black, verrucose.................. 6
5. Median spore wall reticulate........... 9. *S. illinoiense*
5. Median spore wall scrobiculate........ 11. *S. indicum*
   6. Diameter vegetative cells 65–72μ.... 7. *S. ventersicum*
   6. Diameter vegetative cells 70–90μ.... 8. *S. melanosporum*

Descriptions of Species

1. Sirogonium tenuius (Nordstedt) Transeau 1934. *Ohio Jour. Sci.* 34, p. 420. Nordstedt. *Bot. Notiser* 1882. p. 47 (as *Spirogyra stictica* var. *tenuior*).

Vegetative cells 32–36μ x 50–135μ; 2 to 5 chromatophores, nearly straight; conjugation direct between shortened and more or less reflexed gametangia, separated by vegetative cells; receptive gametangia inflated to 60μ; zygospores ellipsoid varying to ovoid, 47–50μ x 60–88μ; median spore wall yellow, smooth.

United States: Oklahoma; Texas; Arkansas; Florida.

Argentina, Córdoba; Brazil, Mato Grosso; Burma.

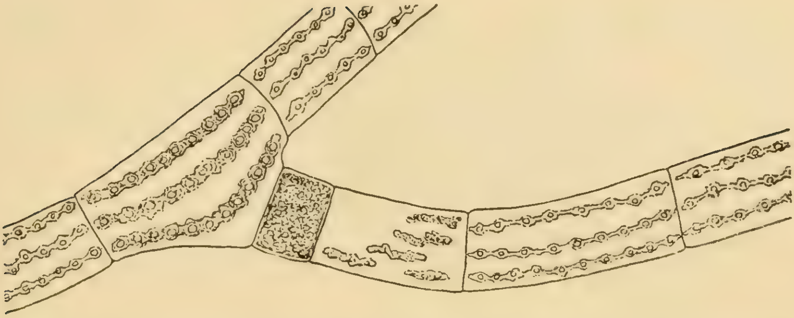


FIG. G.—Conjugation through end wall of male gametangial filament in *Sirogonium sticticum*. Specimen and drawing from C. E. Taft.

2. SIROGONIUM STICTICUM (Engl. Bot.) Kützing 1843. *Phycologia Generalis,* p. 278.

Vegetative cells 38–56μ x 80–300μ; chromatophores 3–6, nearly straight, or making .5 turn; conjugation direct between usually shortened and more or less reflexed gametangia; receptive gametangia inflated to 72μ; spores ellipsoid, sometimes more or less ovoid, 41–67μ x 68–127μ; median spore wall smooth, yellow. (Pl. XL, Figs. 1–4.)

Widely distributed in Europe, Asia, Africa, South America, Australia, and in the United States, and southern Canada. The numbers of chromatophores, cell diameters, and spore dimensions are highly variable.

3. SIROGONIUM MEGASPORUM (Jao) Transeau 1944. *Ohio Jour. Sci.* **44**, p. 244. *Sinensia.* **6**, p. 645, Pl. 12 (as *S. sticticum* var. *megasporum*). 1935.

Vegetative cells 48–55μ x 90–385μ; chromatophores 3 to 4, sometimes 2, straight, or making .5 turn in the cell; conjugation direct, gametangia shortened, reflexed, and more or less inflated on the inner side; receptive gametangia inflated up to 100μ; zygospores ellipsoid to ovoid, 70–85μ x 100–122μ; median spore wall smooth, yellowish-brown at maturity. (Pl. XL, Fig. 5.)

United States: Texas, Bastrop, April 17, 1938 (Taft Coll.).

China, Szechwan; South America, Ecuador, near Quito (Prescott Coll.).

4. SIROGONIUM FLORIDANUM (Transeau) G. M. Smith 1933. *Freshwater Algae of the United States,* p. 557. Transeau. *Ohio Jour. Sci.* **16**, p. 30. 1915.

Vegetative cells 56–66μ x 120–335μ; 4–5 chromatophores, nearly straight, or making a half turn; conjugation direct; gametangia short-

ened and reflexed; receptive gametangia inflated up to 135μ; zygospores ellipsoid, 75–105μ x 95–135μ; median spore wall yellow and smooth.

United States: Florida. Original collection by John Donnell Smith, March, 1878, in southwest part of the peninsula; again collected by L. H. Tiffany in the same region in April, 1933.

South Africa, Cape Town (E. L. Stephens Coll.).

5. Sirogonium pseudofloridanum (Prescott) Transeau 1944. *Ohio Jour. Sci.* **44**, p. 243. *Farlowia.* **1**, pp. 360–61, Fig. 1. 1944.

Vegetative cells 51–60μ x 150–275μ, each with 4 to 5 chromatophores; straight, or making up to 1.5 turns in the cell; receptive gametangia somewhat inflated; zygospores ellipsoid, 63–70μ x 100–120μ; median wall brown, finely corrugate and granulate. (Pl. XL, Fig. 6.)

United States: Wisconsin, Vilas County.

6. Sirogonium ceylanicum Wittrock 1889. Wittrock and Nordstedt Algae Exsiccatae, No. 358.

Vegetative cells 69–75μ x 140–300μ; 7 chromatophores, nearly straight; conjugation direct between reflexed gametangia; receptive gametangia inflated, 120–165μ x 135–300μ; zygospores ellipsoid, 100–110μ x 135–195μ; median spore wall thick, yellow-brown with minute shallow depressions that have no distinct edges but are easily seen when viewed edgewise.

Ceylon.

7. Sirogonium ventersicum Transeau 1934. *Trans. Amer. Micros. Soc.* **53**, p. 229.

Vegetative cells 65–72μ x 110–250μ; 5 to 8 chromatophores, straight, or making 1 turn; conjugation direct; receptive gametangia inflated to 100–140μ; spores mostly ellipsoid, rarely somewhat ovoid, 80–90μ x 133–152μ; median spore wall brown, densely and irregularly verrucose. (Pl. XL, Fig. 7.)

South Africa, Transvaal, Ventersdorp.

8. Sirogonium melanosporum (Randhawa) Transeau 1944. *Ohio Jour. Sci.* **44**, p. 243. *Proc. Indian Acad. Sci.* **8**, p. 364. 1938.

Vegetative cells 70–90μ x 140–260μ, each with 6 to 9 nearly straight chromatophores; conjugation direct; receptive gametangia inflated up to 120–166μ; zygospores usually ellipsoid, 90–110μ x 140–160μ; median spore wall brown to black, verrucose. (Pl. XL, Fig. 8.)

United States: Mississippi, Greenville, August, 1945 (L. A. Whitford Coll.).

India, Fyzabad, Upper Punjab, September-October.

Differs from *S. ventersicum* in being larger in all dimensions, and in having a black rather than a brown median spore wall.

9. SIROGONIUM ILLINOIENSE (Transeau) G. M. Smith 1933. *Freshwater Algae of the United States,* p. 557. Transeau. *Amer. Jour. Bot.* **1**, p. 296, Figs. 1–3. 1914.

Vegetative cells 65–85μ x 100–310μ; 6 to 9 chromatophores, nearly straight or making up to 1 turn in the cell; both gametangia more or less reflexed, the receptive one inflated; zygospores ellipsoid, 85–115μ x 140–190μ; median wall yellow with scattered protuberances connected by a more or less prominent reticulum. (Pl. XL, Figs. 12–13.)

United States: Originally collected at Lerna, Illinois, from a single prairie pond now destroyed; not found elsewhere in central Illinois during 7 years of collecting. Recently collected in eastern Oklahoma by C. E. Taft.

10. SIROGONIUM HUI (Li) Transeau 1944. *Ohio Jour. Sci.* **44**, p. 244. *Bull. Fan Mem. Inst. Biol., Botany.* **8**, p. 91 (as *Spirogyra hui* Li). 1938.

Vegetative cells 82–108μ x 140–256μ, with plane end walls; 5 to 10 chromatophores; receptive gametangia inflated to 150μ; zygospores ellipsoid to ovoid, 88–115μ x 133–192μ; outer spore wall thin, colorless; median wall of 2 layers; outer layer thin, irregularly wrinkled; inner layer yellow, verrucose; the inner wall thin and transparent. Akinetes 86–92μ x 64–96μ are common. (Pl. XL, Figs. 10–11.)

China, Kiangsi.

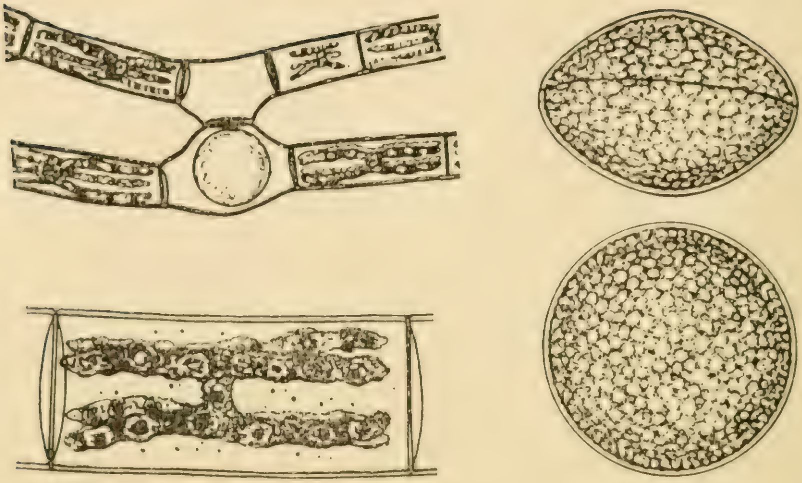
This is the largest species in the genus and the only one with a double median spore wall. Described as a *Spirogyra,* but the figure is sufficient evidence that it should be classified as a *Sirogonium.* The description has been amended slightly after examination of the type material.

11. SIROGONIUM INDICUM Singh 1938. *Jour. Indian Bot. Soc.* **17**, p. 384, Fig. 6B.

Vegetative cells 65–80μ in diameter, with approximately 7 chromatophores which are nearly straight; conjugation scalariform between reflexed gametangia; receptive gametangia greatly inflated; zygospores ellipsoid, 75–90μ x 135–165μ; median spore wall thick, yellow, and scrobiculate. (Pl. XL, Fig. 9.)

India.

12. SIROGONIUM PHACOSPORUM Skuja 1949. *Nova Acta Soc. Sci. Upsali.* Ser. 3, **14**, p. 103, Pl. 22, Figs. 1–5.



Figs. H to K.—*Sirogonium phacosporum* vegetative cells, conjugation pattern, and 2 views of spore with markings. After Skuja.

Vegetative cells 54–60μ x 100–370μ; chromatophores usually 4, rarely 3, straight or slightly curved; conjugation direct; receptive gametangia inflated, 95–110μ x 150–190μ; zygospores lenticular, 70–100μ x 60–70μ; median spore wall 2–3μ thick, yellow or brownish yellow, finely reticulate-scrobiculate. As in other species, spores sometimes deformed by the gametangial walls.

Burma, near Rangoon, in running water, 1936. (L. P. Khanna Coll.).

List of the Species of SIROGONIUM with Number

ceylanicum Wittrock 1889 6
floridanum (Transeau) G. M. Smith 1933 4
hui (Li) Transeau 1944 10
illinoiense (Transeau) G. M. Smith 1933 9
indicum Singh 1938 11
megasporum (Jao) Transeau 1944 3
melanosporum (Randhawa) Transeau 1944 8
phacosporum Skuja 1949 12
pseudofloridanum (Prescott) Transeau 1944 5
sticticum (Engl. Bot.) Kützing 1843 2
tenuius (Nordstedt) Transeau 1934 1
ventersicum Transeau 1934 7

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INDEX

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PLATES

PLATE I

Reproductive Structures of Zygnemataceae

Fig. 1.—Akinetes of *Spirogyra juergensii* from Crystal Springs, Mississippi, April, 1925. The usual form of akinetes in this species is similar to that of the vegetative cells. Fig. 2.—Akinetes of a *Zygnema* found at Arcadia, Florida, February, 1931. Fig. 3.—Akinetes and zygospore of *Spirogyra farlowii* from Topinobee, Michigan, July, 1934. Figs. 4–5.—Vegetative cell and two aplanospores of *Spirogyra wrightiana* from Parahiba, Brazil, July, 1934. Fig. 6.—Vegetative cell and two aplanospores of *Zygnema frigidum* from Smithville, Oklahoma, May, 1932. Fig. 7.—Aplanospores of *Spirogyra pratensis* from Charleston, Illinois, May, 1912. On two of the sporangia figured are outgrowths that suggest the initials of conjugating tubes. In many species these outgrowths are alternately or spirally arranged in successive cells. When present they occur in only some of the sporangia. Fig. 8.—Zygospores and parthenospores of *Zygnema stellinum* from Charleston, Illinois, May, 1912. This camera-lucida drawing also demonstrates the distance between filaments through which conjugation may take place. Fig. 9.—Aplanospores and zygospores of *Zygnema cruciatum* from Coffeen, Illinois, May, 1915. Note that aplanospores occur in both male and female filaments. Fig. 10.—Four zygospores of *Mougeotia drouetii* from Fortaleza, Ceará, Brazil, October, 1935. This figure exemplifies several species in which the cytoplasmic residues form a film enclosing the zygospores.

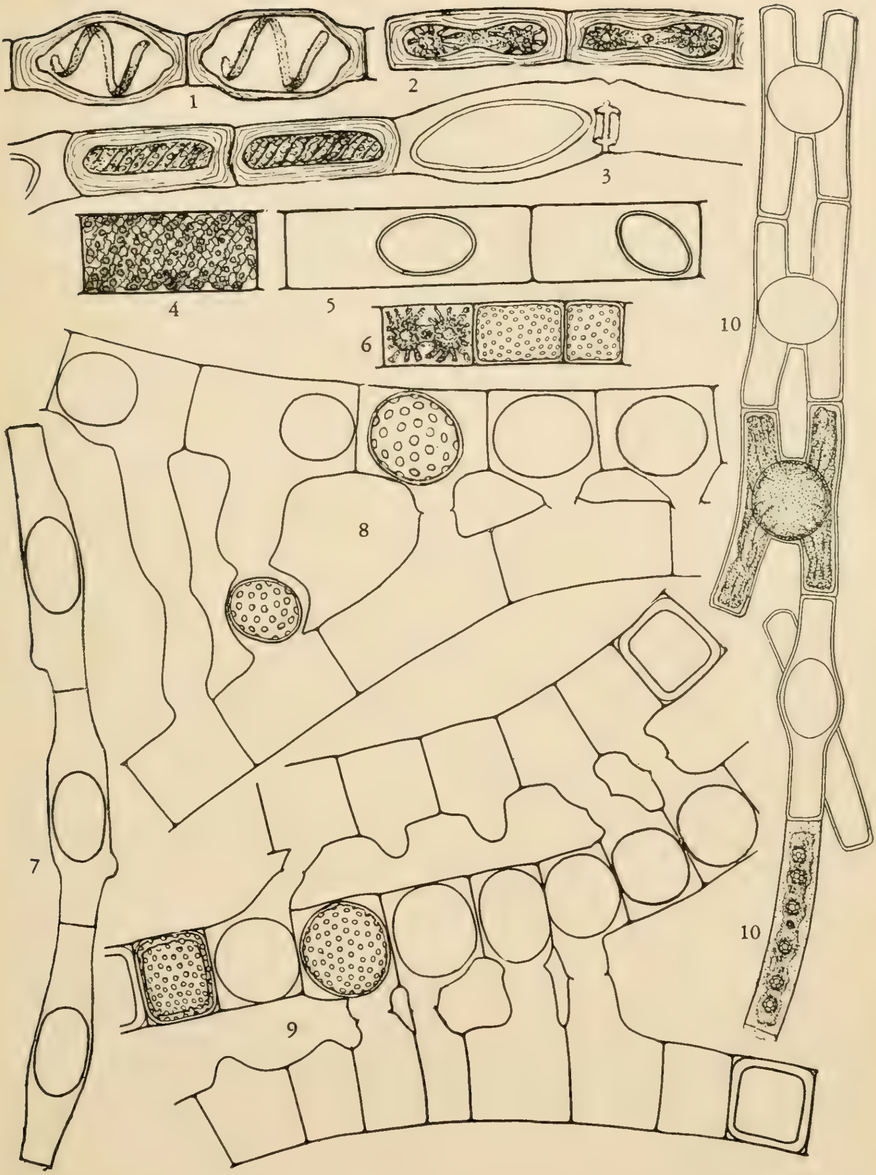
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PLATE II

Zygnema

Fig. 1.—Usual and unusual chromatophores in a filament of *Zygnema* collected near Fort Myers, Florida. Fig. 2.—Chromatophore patterns in filaments from West Point, Mississippi, and Pittsburgh, Pennsylvania. Fig. 3.—*Z. oveidanum* from Florida, zygospore, parthenospore, and appearance of chromatophores during conjugation. Fig. 4.—*Z. himalayense* from India, scalariform and lateral conjugation and zygospores. In lateral conjugation the gametes unite through the end walls. After Randhawa. Figs. 5–6.—*Z. laevisporum*, vegetative cell, scalariform and lateral conjugation, and mature zypospore from Falmouth, Massachusetts. After Jao. Fig. 7.—*Z. decussatum*, three zygospores and adjoining gametangia from Charleston, Illinois. Fig. 8.—*Z. conspicuum*, zygospores and gametangia, from central Illinois. Fig. 9.—*Z. lawtonianum*, zygospores and gametangia from Medicine Park, Oklahoma. After Taft. Figs. 10–11.—*Z. verrucosum*, zygospores, gametangia, and details of spore wall, from Szechwan, China. After Jao. Fig. 12.—*Z. chungii*, zygospore patterns from Wuchang, China. After Li.

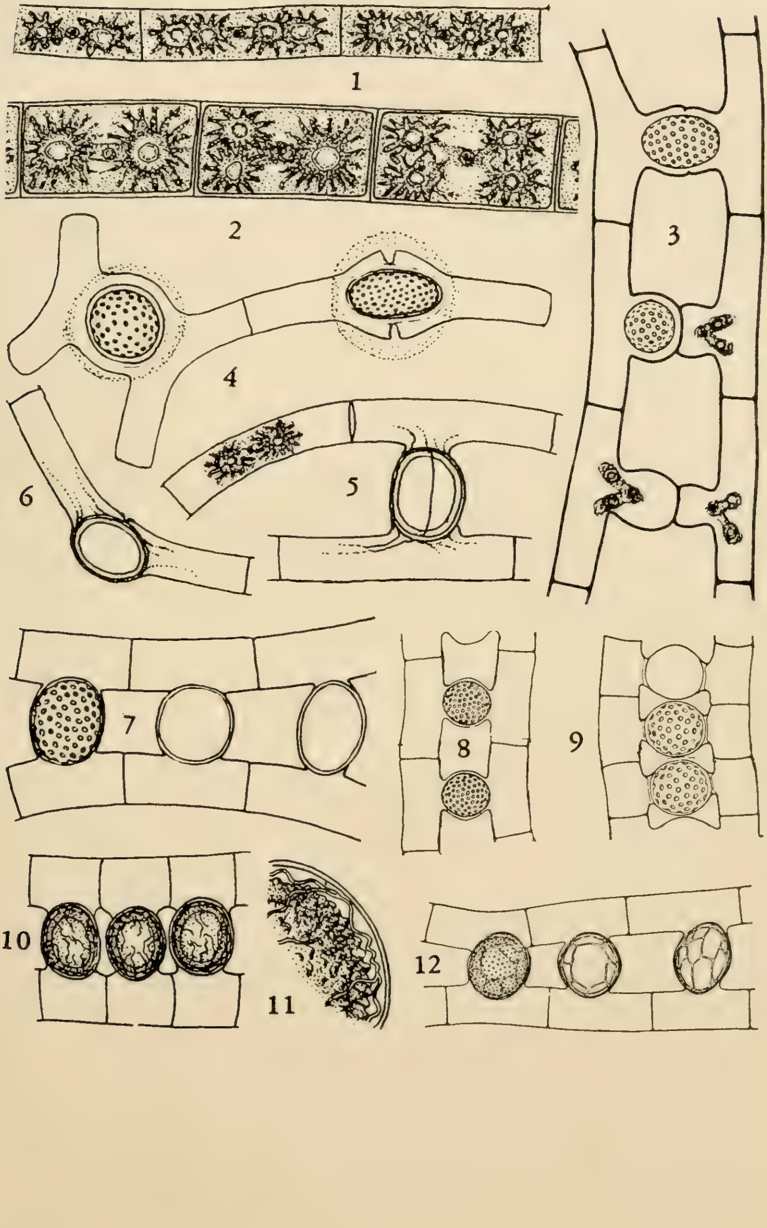
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PLATE III

Zygnema

Fig. 1.—*Z. sinense,* zygospores and gametangia from Szechwan, China. After Jao. Figs. 2–3.—*Z. globosum,* conjugation pattern and detail of spore walls from Bohemia. After Czurda. Fig. 4.—*Z. adpectinatum,* gametangia and zygospore from Charleston, Illinois. Fig. 5.—*Z. areolatum,* gametangia and zygospores from Smithville, Oklahoma. Fig. 6.—*Z. pectinatum,* scalariform and lateral conjugation, aplanospore, and zygospores with spore wall markings, from Coffeen, Illinois. Fig. 7.—*Z. excrassum,* zygospores and gametangia from Casey, Illinois. Fig. 8.—*Z. neopectinatum,* gametangia and zygospore from Illinois. Figs. 9–10.—*Z. giganteum,* aplanospore, zygospores and parthenospores from Punjab, India. Modified after Randhawa. Figs. 11–12.—*Z. gedeanum,* lateral conjugation, zygospore, and parthenospores from Java. After Czurda. Figs. 13–14.—*Z. czurdae,* zygospores after partial disintegration of the gametangial walls, from Punjab, India. After Randhawa.

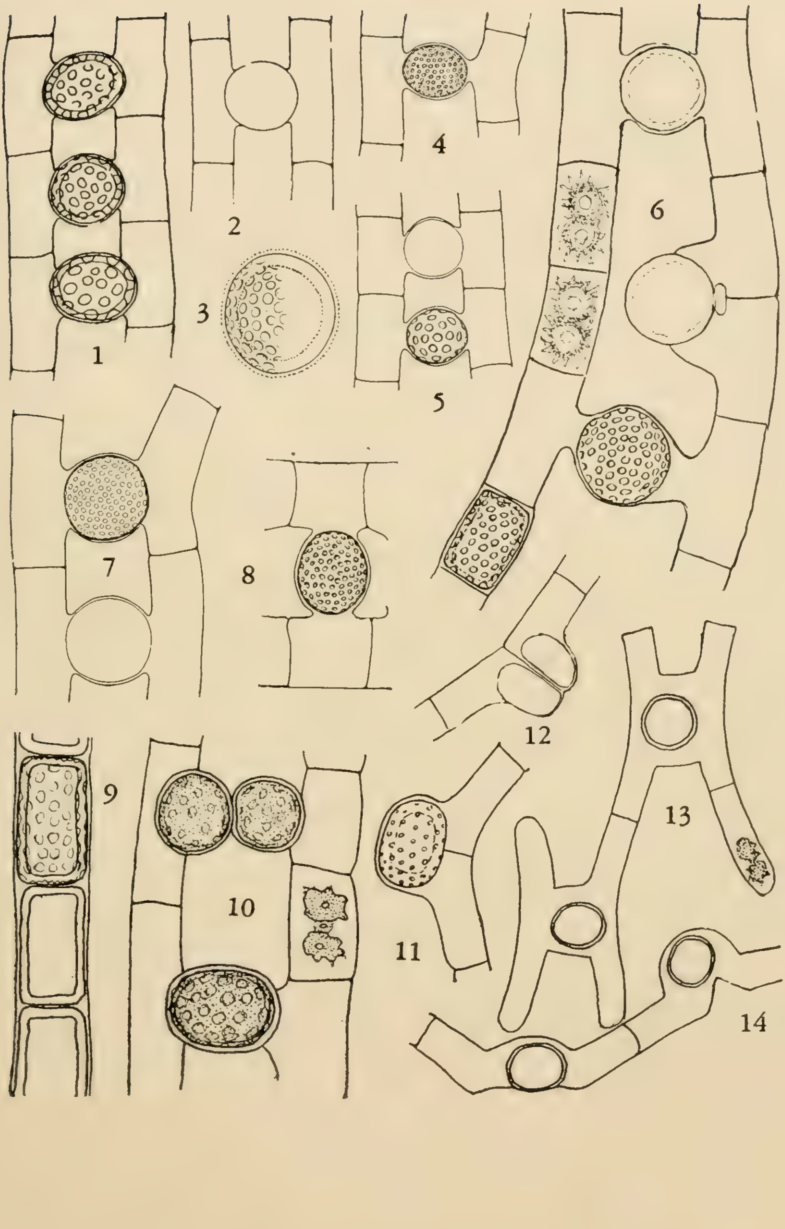
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PLATE IV

Zygnema

Figs. 1–2.—*Z. synadelphum*, zygospores and vegetative cells enclosed by pectic sheath with prominent structural lines. Figure 1 from Latvia, after Skuja; Fig. 2 from Douglas Lake, Michigan. Figs. 3–4.—*Z. coeruleum*, zygospores and gametangia, and spore wall pattern, from Bohemia. After Czurda. Fig. 5.—*Z. kiangsiense*, zygospores and gametangia from China. After L. C. Li. Fig. 6.—*Z. ralfsii*, conjugation pattern after G. S. West. Fig. 7.—*Z. micropunctatum*, zygospore and gametangia from Douglas Lake, Michigan. Figs. 8–9.—*Z. circumcarinatum*, zygospore and details of spore wall from Bohemia. After Czurda. Fig. 10.—*Z. pawhuskae*, gametangia and zygospores from Oklahoma. After Taft. Fig. 11.—*Z. carinatum*, zygospores and gametangia from Oklahoma. Fig. 12.—*Z. extenue*, zygospores and beginning of lateral conjugation from Szechwan, China. After Jao. Fig. 13.—*Z. tholosporum*, zygospore from Uruguay. After Magnus and Wille. Figs. 14–15.—*Z. tenue*, zygospores, gametangia, and details of spore wall from China. After Jao. Fig. 16.—*Z. cylindrospermum*, zygospores and gametangia from the Shetland Islands. After W. & G. S. West. Figs. 17–18.—*Z. hausmannii*, zygospores and gametangia from Austria. After Czurda.

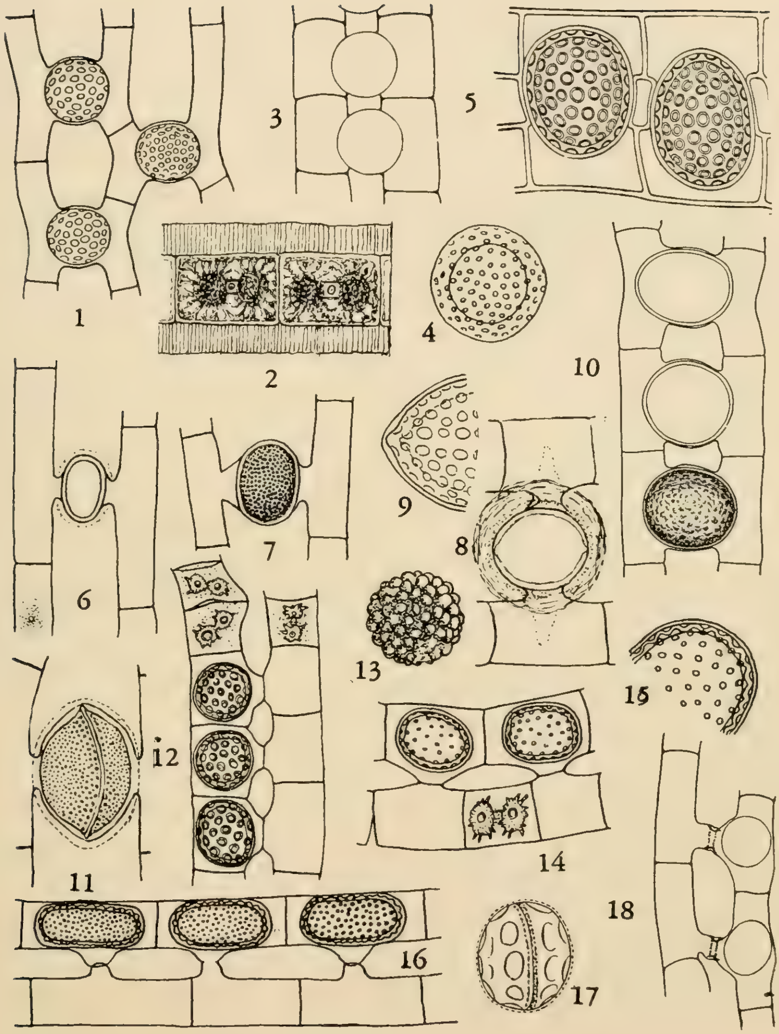
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PLATE V

Zygnema

Fig. 1.—*Z. substellinum*, vegetative cells and the enlarged receptive gametangia from Bartlesville, Oklahoma. Fig. 2.—*Z. luteosporum*, gametangia and zygospore from Bohemia. After Czurda. Fig. 3.—*Z. flavum*, zygospore, vegetative cells, and akinete from Eden, Texas. After Taft. Fig. 4.—*Z. calosporum*, zygospores and vegetative cell from Szechwan, China. After Jao. Fig. 5.—*Z. vaucherii*, gametangia and zygospores from Cape Cod, Massachusetts. Fig. 6.—*Z. normani*, zygospore and gametangia from Norman, Oklahoma. After Taft. Fig. 7.—*Z. subcruciatum*, zygospores and gametangia from China. After Jao. Figs. 8–9.—*Z. germanicum*, zygospores and gametangia from Germany. After Czurda. Figs. 10–12.—*Z. insigne*, conjugation patterns and zygospores. After Jao, and de Bary. Figs. 13–14.—*Z. fanicum*, scalariform conjugation and zygospores from China. After Li, and Jao. Fig. 15.—*Z. subfanicum*, zygospore and gametangia from China. After Jao. Fig. 16.—*Z. stellinum*, aplanospores and zygospores from Starkville, Mississippi, April, 1925. Note relative length of aplanosporangia and gametangia. (See also Plate I and Plate VI.)

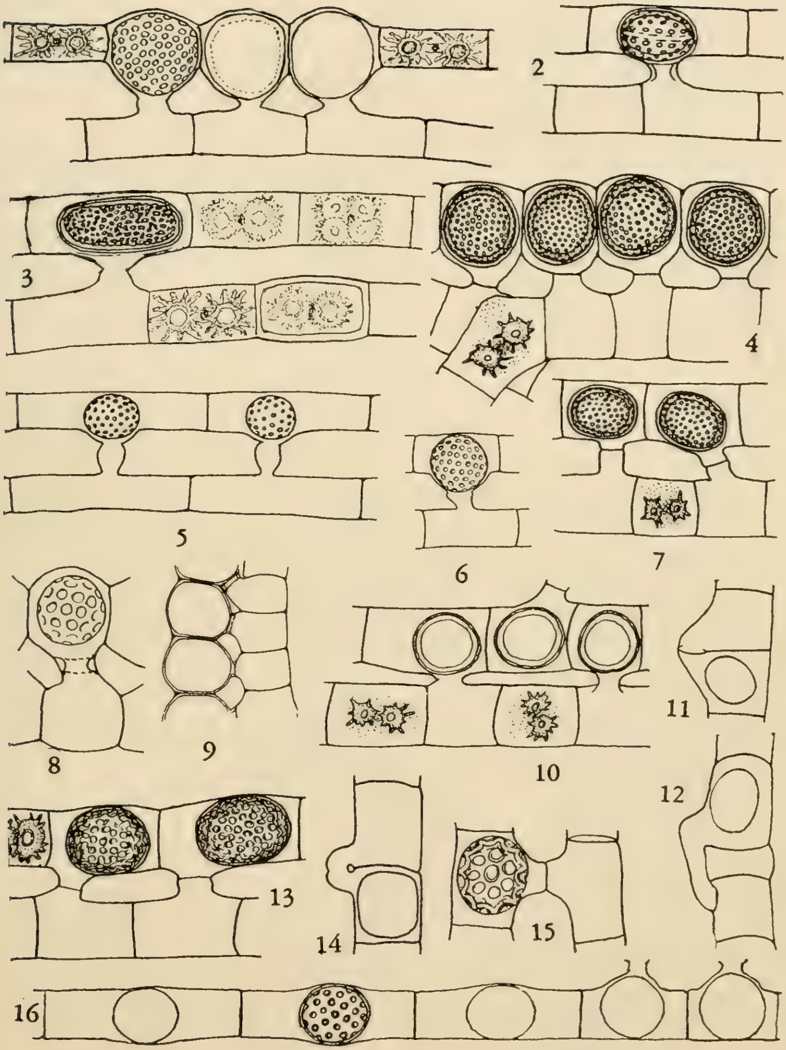
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PLATE VI

Zygnema

Fig. 1.—*Z. stellinum*, zygospores formed by lateral and scalariform conjugation from Illinois. (See also Plates I and V for figures of parthenospores and aplanospores.) Fig. 2.—*Z. cylindrosporum*, zygospores and gametangia from Macedonia. After Czurda. Fig. 3.—*Z. bohemicum*, gametangia and zygospores from Bohemia. After Czurda. Fig. 4.— *Z. mirandum*, zygospores, vegetative cell, and akinete, from Austin, Texas. After Taft. Fig. 5.—*Z. inconspicuum*, zygospores and gametangia from Manchuria. After Czurda. Figs. 6–7.—*Z. crassiusculum*, zygospores and details of spore wall from Cape Town, South Africa. Fig. 8.—*Z. chalybeospermum*, lateral and scalariform conjugation, with resulting zygospores from Bohemia. Modified from Czurda. Figs. 9–10.—*Z. cyaneum*, scalariform and lateral conjugation from Bohemia. After Czurda. Figs. 11–13.—*Z. collinsianum*, zygospores in relation to gametangia, zygospore, and aplanospore with details of spore wall markings from central Illinois. Fig. 14.—*Z. excompressum*, zygospores and spore markings from Bohemia. After Czurda. Fig. 15.—*Z. azureum*, zygospores and gametangia from Medford, Oklahoma. After Taft. Fig. 16.—*Z. carinthiacum*, zygospore, gametangia, and spore wall markings from Szechwan, China. After Jao. Fig. 17.—*Z. peliosporum*, zygospores and gametangia from Alabama.

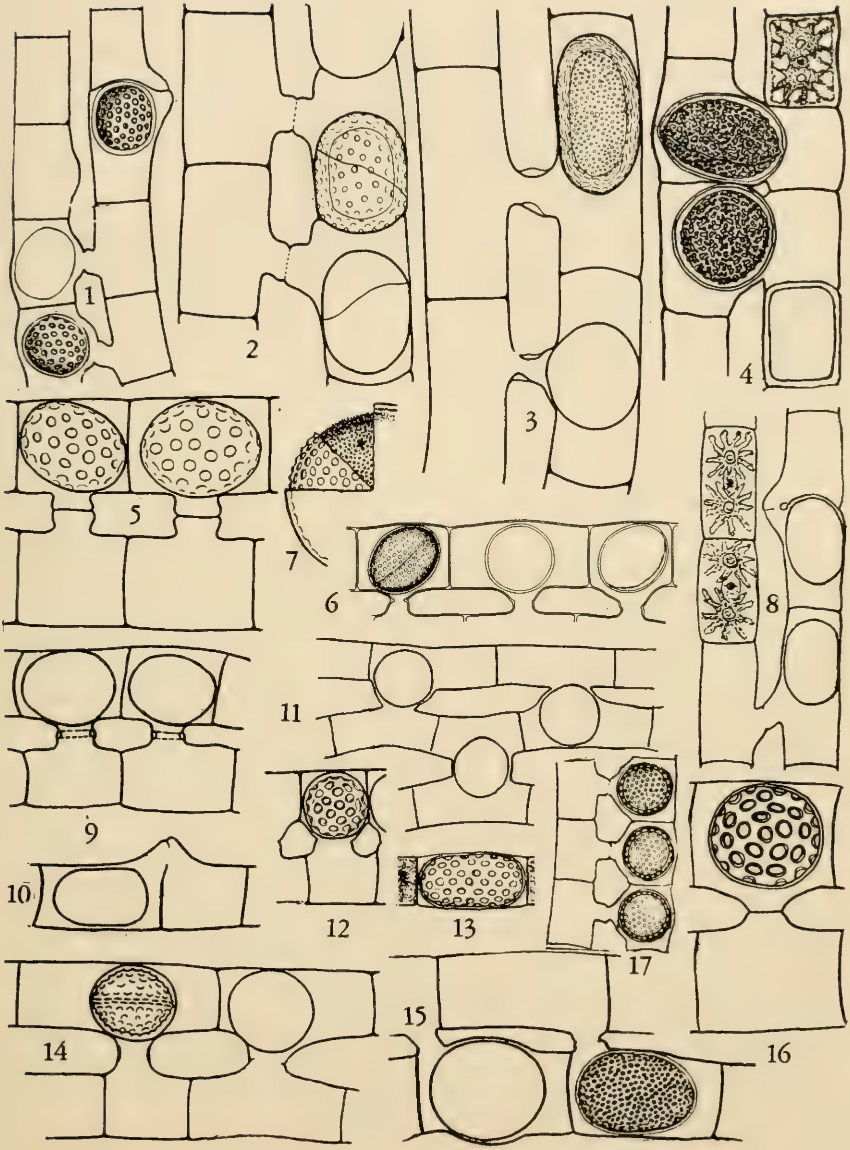
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PLATE VII

Zygnema

Fig. 1.—*Z. pawneanum,* gametangia and zygospores from Oklahoma. After Taft. Fig. 2.—*Z. ornatum,* gametangia and zygospores from Nanking, China. After L. C. Li. Fig. 3.—*Z. excommune,* gametangia and zygospores from Bohemia. After Czurda. Fig. 4.—*Z. borzae,* aplanospore and sporangium from Transylvania. After Krieger. Figs. 5–7.—*Z. spontaneum,* vegetative cell, akinete, early stages of aplanospore development, and mature spores from South Africa. The last figure, of a specimen from China, is after Jao. Fig. 8.—*Z. irregulare,* aplanospore and sporangium from Brandenburg, Germany. After Krieger. Fig. 9.—*Z. cylindricum,* aplanospores and vegetative cell from Hilliards, Ohio. Fig. 10.—*Z. schwabei,* aplanospore from southern Chile. After Krieger. Fig. 11.—*Z. sterile,* akinetes with laminate walls from Madison County, Ohio. Fig. 12.—*Z. hypnosporum,* aplanospores in a filament having a thick pectic sheath with radial structural lines from Rhodesia, South Africa. After Rich. Fig. 13.—*Z. subcylindricum,* aplanospore and sporangium from Bohemia. After Czurda. Fig. 14.—*Z. quadrangulatum,* aplanospores from Hunan, China. After Jao. Fig. 15.—*Z. kwangtungense,* zygospores and gametangia from China. After Ley. Figs. 16–18.—*Z. terrestre,* two forms of aplanospores and a zygospore from Fyzabad, India. After Randhawa.

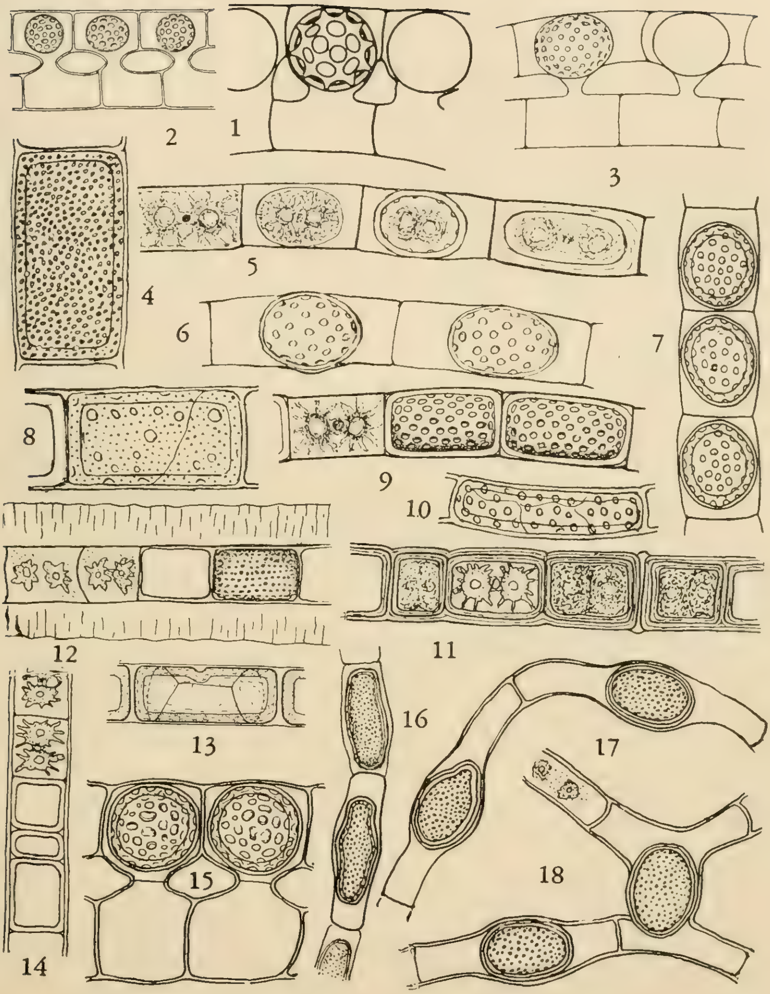

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PLATE VIII

Zygnemopsis

Figs. 1–2.—*Z. sikangensis,* vegetative cells and zygospores from Yünnan, China. After L. C. Li. Figs. 3–5.—*Z. orientalis,* vegetative cells, immature and mature zygospores from northern India. After Carter. Figs. 6–7.—*Z. gracilis,* vegetative cells and aplanospores from Fyzabad, India. After Randhawa. Figs. 8–9.—*Z. floridana,* zygospores in face and lateral views, from Florida. Figs. 10–11.—*Z. minuta,* zygospore and aplanospores from Michigan. Figs. 12–14.—*Z. desmidioides,* zygospores, face and edgewise views, and vegetative cells from Latvia. After Skuja. Figs. 15–17.—*Z. columbiana,* zygospores in face and edgewise views, and an aplanospore from British Columbia. Figs. 18–21.—*Z. americana,* various forms of zygospores and a pair of parthenospores from Ontario, Canada. Figs. 22–23.—*Z. tiffaniana,* zygospores from Fort Myers, Florida. Fig. 24.—*Z. sinensis,* vegetative cell and zygospore from Hupeh, China. Fig. 25.—*Z. splendens,* zygospore from Fyzabad, India. After Randhawa. Figs. 26–27.—*Z. indica,* zygospore and aplanospore from Hamira, India. After Randhawa. Figs. 28–29.—*Z. wuchangensis,* zygospore and vegetative cell from Hupeh, China. After L. C. Li.

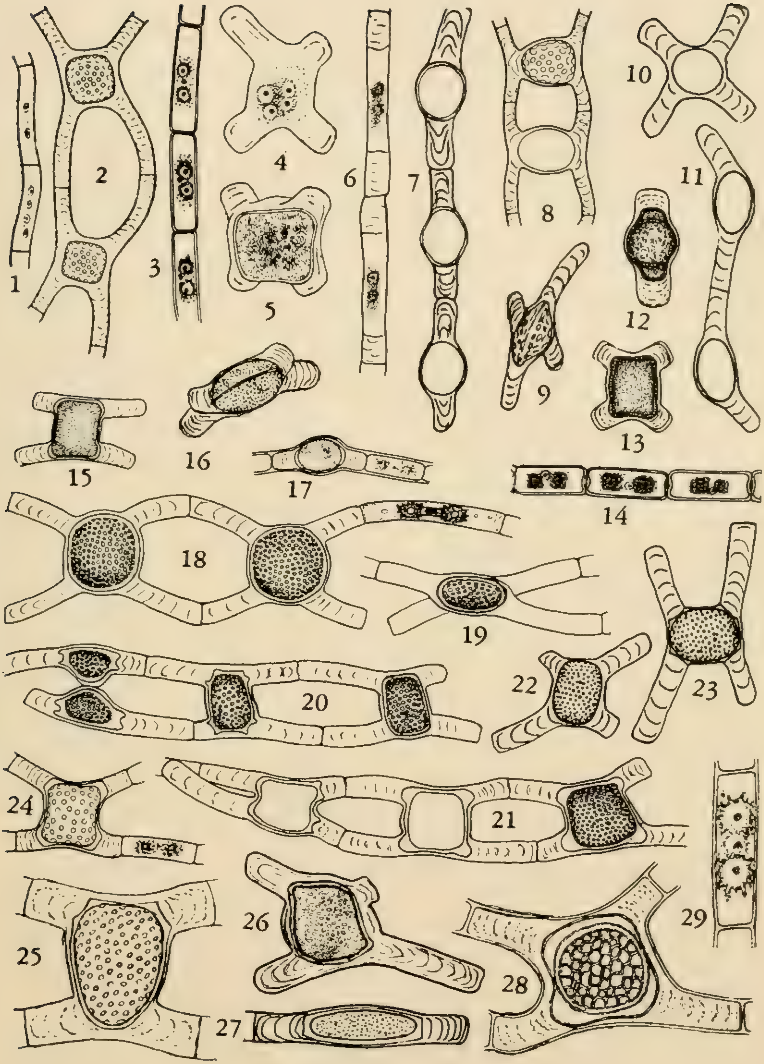
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PLATE IX

Zygnemopsis

Fig. 1.—*Z. stephensiae,* two zygospores from Cape Colony, South Africa. Figs. 2–3.—*Z. iyengarii,* zygospores and aplanospores from Fyzabad, India. Drawn from type material. Figs. 4–5.—*Z. quadrata,* zygospores from Szechwan, China. After Jao. Figs. 6–7.—*Z. sphaerospora,* zygospores from Fyzabad, India. After Randhawa. Figs. 8–9.—*Z. lamellata,* face and lateral views of zygospores from India. Drawn from type material. Figs. 10–11.—*Z. transeauiana,* aplanospores and vegetative cell from Fyzabad, India. After Randhawa. Figs. 12–15.—*Z. decussata,* vegetative cells, zygospores, parthenospores, and aplanospores from Ilinois. Fig. 16.—*Z. spiralis,* group of zygospores from Michigan. After Prescott. Fig. 17.—*Z. fertilis,* aplanospores from South Africa. After Fritsch and Rich. Figs. 18–21.—*Z. pectinata,* variations in chromatophores and aplanospores from Kentani, South Africa. Fig. 22.—*Z. hodgettsii,* immature aplanospores from Stellenbosch, South Africa. After Hodgetts.

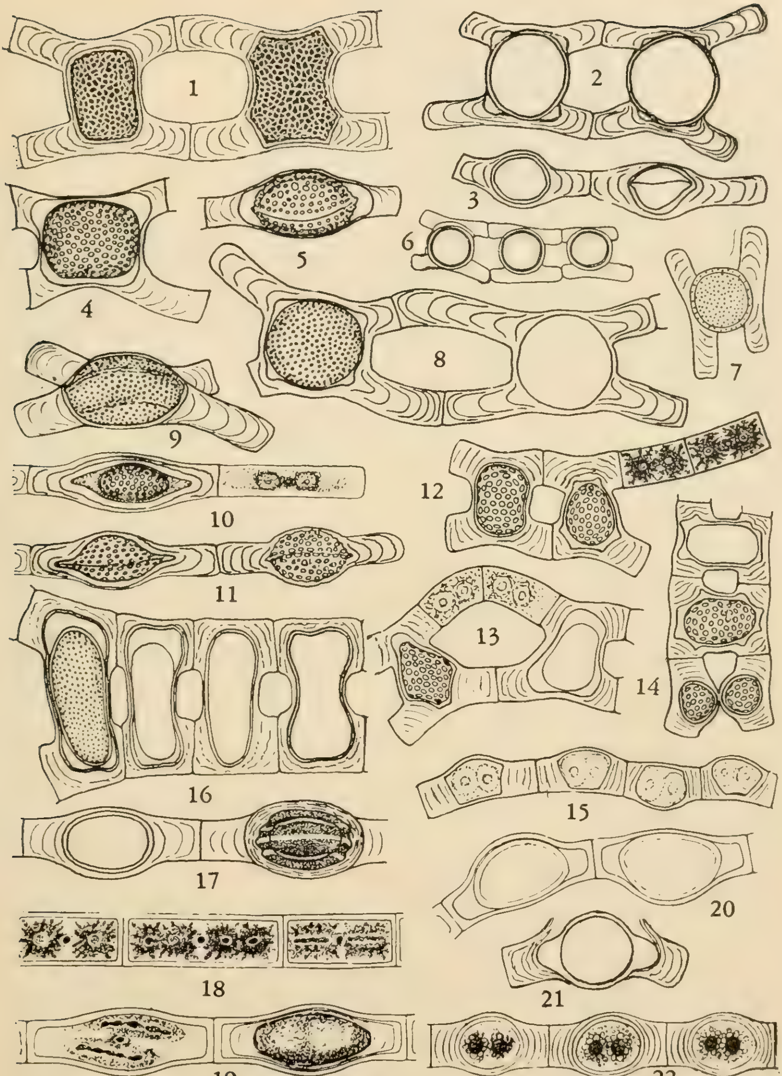
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PLATE X

Hallasia and Zygogonium

Figs. 1–9.—*Hallasia reticulata,* vegetative cells and aplanospores. In some of the aplanospores secondary spores are formed which are released by the separation of the two valves of the aplanospore wall. In Fig. 9 a several-celled sporeling is depicted. After Hallas. Figs. 10–16.—*Zygogonium ericetorum,* vegetative cells, akinetes, aplanospores, and zygospores in various stages of development. All but Fig. 14 are from Longwood, Florida. In Fig. 14 are filaments with an aplanospore and three encysted and united gametes, from Kwangtung, China. Figs. 17–19.—*Z. mirabile,* zygosporangia and vegetative cells from Portuguese West Africa. After G. S. West.

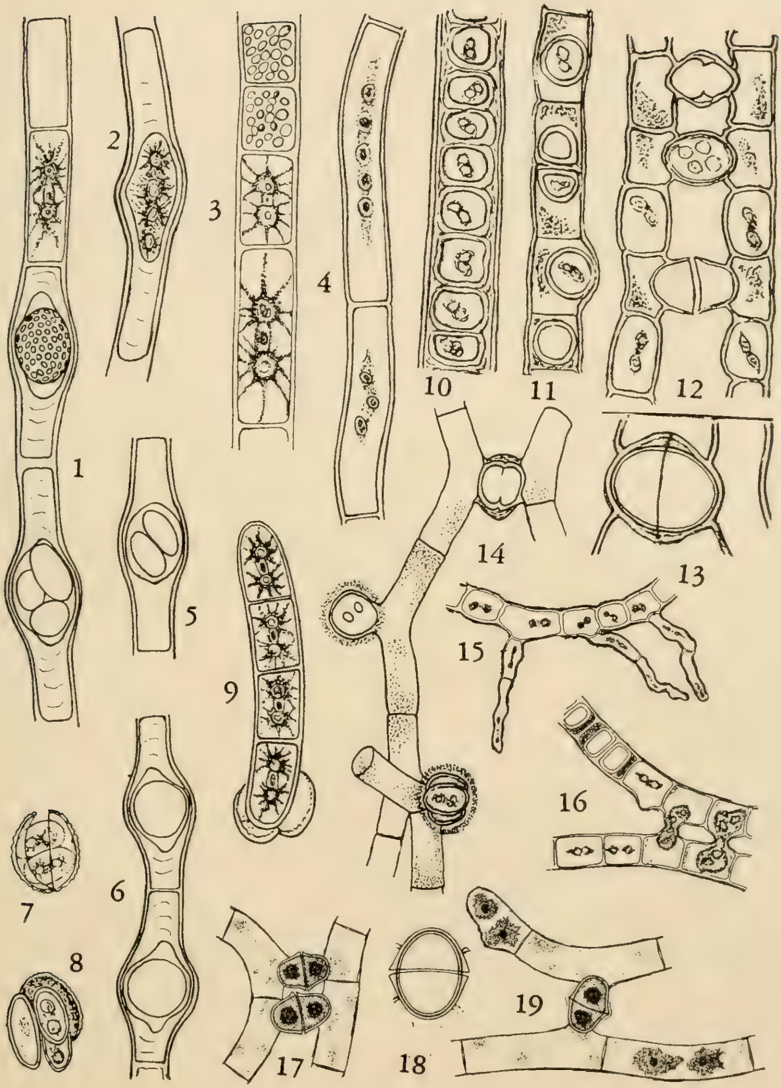
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PLATE XI

Zygogonium

Figs. 1–3.—*Z. pectosum*, zygospores and gametangia, modes of branching, and aplanospore from Louisiana. After Taft. Figs. 4–6.—*Z. hansgirgii*, filaments with aplanospores and spore markings, from India. After Schmidle. Figs. 7–8.—*Z. talguppense*, sporangia and aplanospores from India. After Iyengar. Figs. 9–11.—*Z. capense*, aplanospores and sporangia, details of spore wall, from Stellenbosch, South Africa. After Hodgetts. Fig. 12.—*Z. punctatum*, zygospore and elongated gametangia from Louisiana. After Taft. Figs. 13–15.—*Z. heydrichii*, lateral conjugation and zygospores, release of spore through separation of two halves of sporangium wall, and akinete from Sydney, Australia. After Schmidle. Figs. 16–19.—*Z. kumaoënse*, aplanospores and branching filament from northern India. After Randhawa.

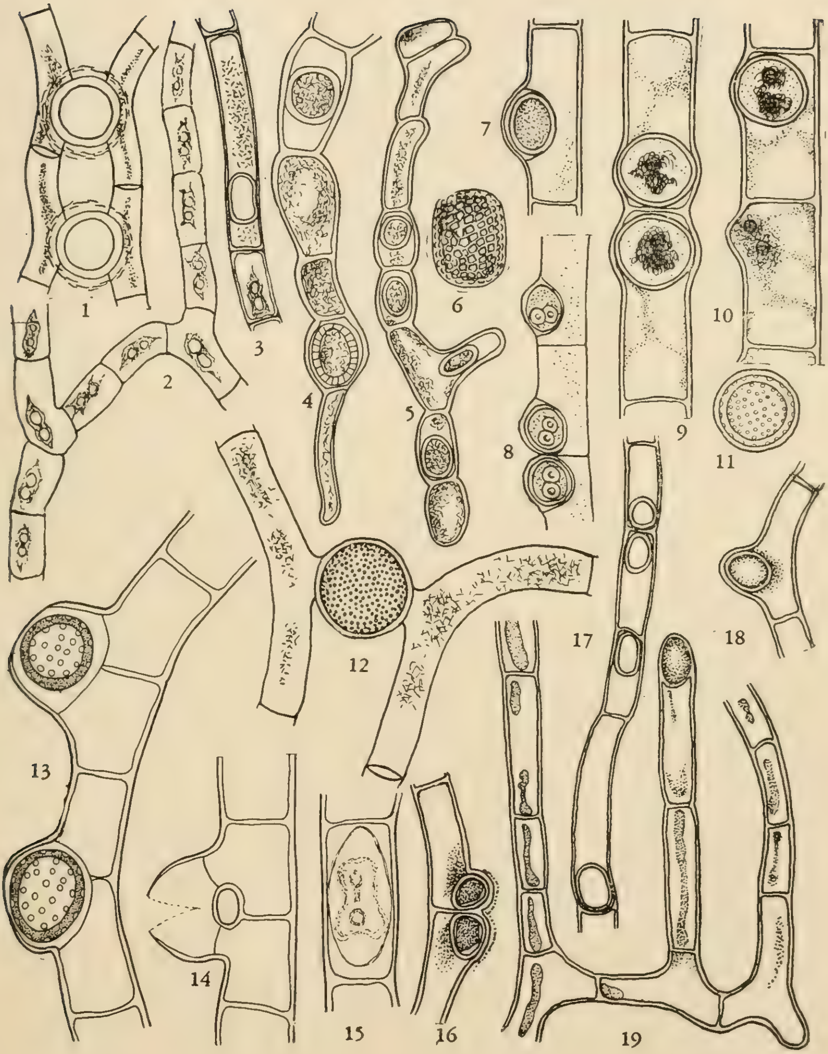
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PLATE XII

Zygogonium, Pleurodiscus, Mougeotiopsis, and Debarya

Figs. 1–5.—*Zygogonium sinense,* zygospores, vegetative cells, parthenospores, lateral conjugation, and resulting zygospore; also remnants of sporangium wall after escape of zygospore; details of spore wall. Figs. 6–8.—*Z. exuvielliforme,* zygospores formed by lateral and scalariform conjugation, and details of spore wall, from Colombia, South America. After Jao. Figs. 9–11.—*Z. plakountiosporum,* zygospores formed by lateral and scalariform conjugation. Note bilateral asymmetry of spore wall markings from Colombia, South America. After Jao. Figs. 12–15.—*Pleurodiscus borinquinae,* vegetative cells with disc-shaped chromatophores; zygospores and details of sporangium and spore walls from Puerto Rico. After Tiffany. Figs. 16–17.—*Mougeotiopsis calospora,* vegetative cells with chromatophores in different positions; zygospores with characteristic deep pits in the spore wall from Latvia. After Skuja. Figs. 18–19.—*Debarya glyptosperma,* arched gametangia and zygospores from Sweden. Figs. 20–21.—*D. ackleyana,* face and side views of zygospores from Michigan. Figs. 22–23.—*D. costata,* zygospores in face and side views from Fyzabad, India. Figs. 24–26.—*D. polyedrica,* zygospores and gametangia from Yünnan, China. After Skuja. Figs. 27–28.—*D. smithii,* vegetative cell and mature zygospore; lower figure shows growth of the two chromatophores and the multiplication of pyrenoids during the early stages of conjugation, from Fresno, California. Figs. 29–30.—*D. hardyi,* conjugating gametangia and immature spore; cannot be placed in this genus with certainty until mature zygospores are found.

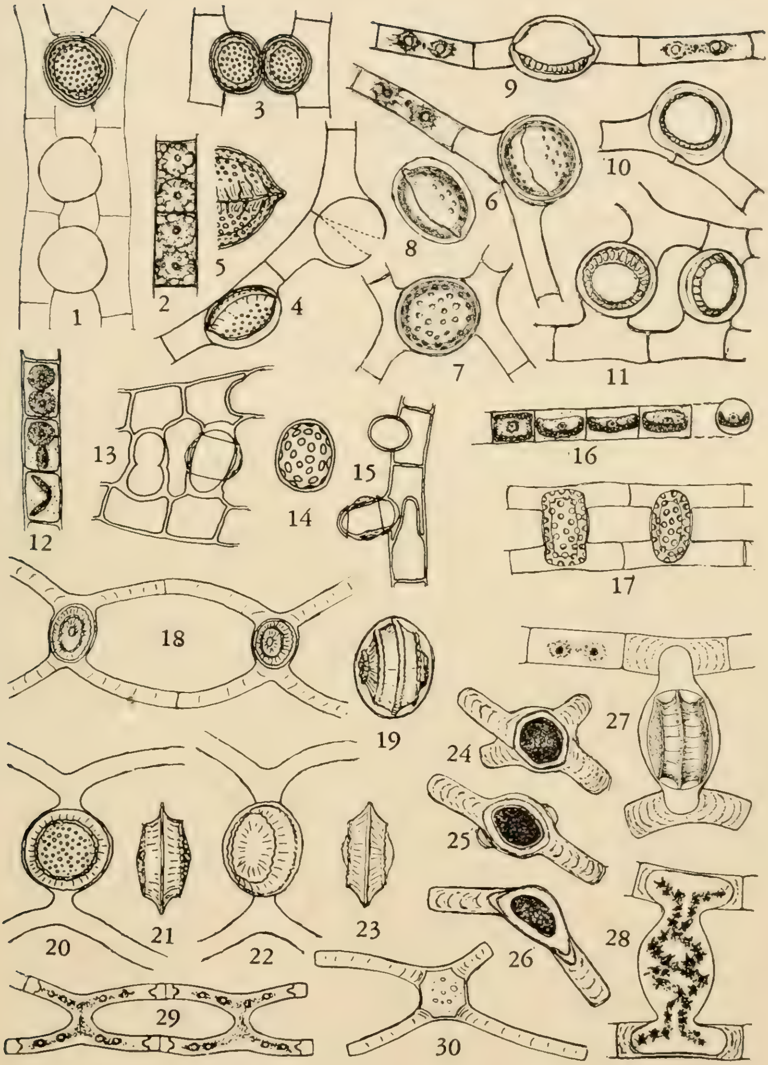
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PLATE XIII

Mougeotia

Fig. 1.—*M. angusta,* gametangia and zygospore. After Hassall. Fig. 2.—*M. tenuissima,* zygospore and gametangia. After de Bary. Figs. 3–5—*M. parvula,* zygospores and subtending gametangia from Finland; third figure, aplanospore and sporangium from Burgaw, North Carolina. Figs. 6–9.—*M. tubifera,* figures in order illustrate an early stage in conjugation; usual form of mature zygospore; zygospore resulting from conjugation through lateral wall of one of the tubes; the last exemplifies a pair of tubes that failed to unite and produced a pair of parthenospores. Note that the tubes have about the same diameter as the vegetative cells. The cells are too long to be illustrated on this plate. Specimens from Wilmington, North Carolina. Figs. 10–12.—*M. calcarea,* aplanospore, three zygospores, and the form of zygospore which has been distinguished as "bicalyptrata." First two figures after Wittrock. Fig. 13.—*M. recurva,* usual position of zygospore between gametangia. Fig. 14.—*M. ellipsoidea,* zygospore and gametangia. After G. S. West. Figs. 15–17.—*M. adnata,* zygospores resulting from scalariform and lateral conjugation, from India. After Iyengar. Fig. 18.—*M. victoriensis* from Australia, gametangia and zygospore enclosed by thick pectic layer. After West. Fig. 19.—*M. chlamydata,* zygospore with remnants of outer layer of sporangium wall surrounding each half of the conjugating tube, from Ecuador. After Prescott. Fig. 20.—*M. cotopaxiensis,* zygospore pattern, from volcano Cotopaxi, Ecuador. After Prescott.

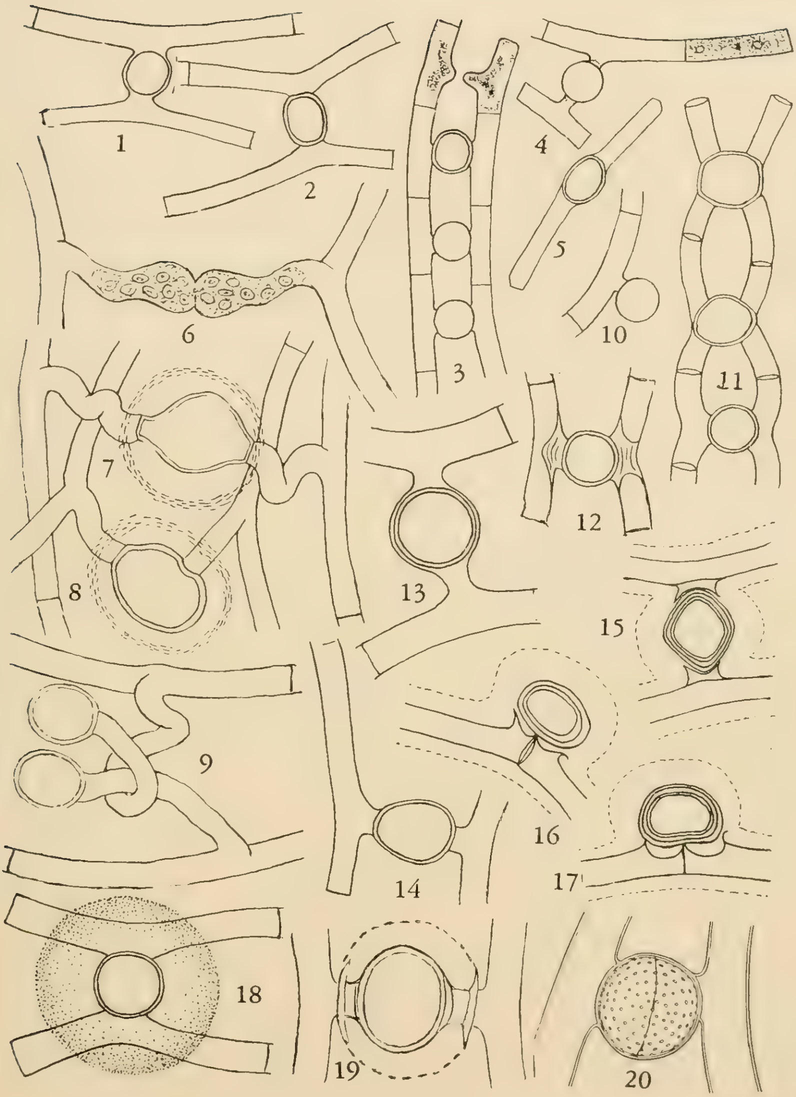
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PLATE XIV

Mougeotia

Fig. 1.—*M. kerguelensis,* zygospores and gametangia from the Kerguelen Islands, in the southern Indian Ocean. After Krieger. Fig. 2.—*M. maltae,* zygospore and gametangia from Latvia. After Skuja. Fig. 3.—*M. reinschii,* zygospore by lateral conjugation, from central Illinois. Figs. 4–6.—*M. sphaerocarpa,* zygospores, parthenospores, and aplanospores from Columbus, Ohio. The walls of the gametangia and tubes are often greatly thickened, and the cytoplasmic residues may form a veil around the zygospore as in Fig. 5. Figs. 7–8.—*M. scalaris,* zygospore by scalariform conjugation and parthenospore after incomplete lateral conjugation, from Michigan. Figs. 9–10.—*M. jogensis,* zygospores after scalariform and lateral conjugation, from India. After Iyengar. Figs. 11–12.—*M. africana,* aplanospore and zygospore from the Philippine Islands. Fig. 13.—*M. hirnii,* zygospore and gametangia from Finland. After Hirn. Fig. 14.—*M. ovalispora,* zygospore and gametangia from Germany. After Krieger. Fig. 15.—*M. macrospora,* zygospore and gametangia from Pennsylvania. After Wolle. Figs. 16–17.—*M. genuflexa,* zygospores by lateral and scalariform conjugation, from Illinois. Fig. 18.—*M. subcrassa,* zygospore and gametangia from Australia. After G. S. West.

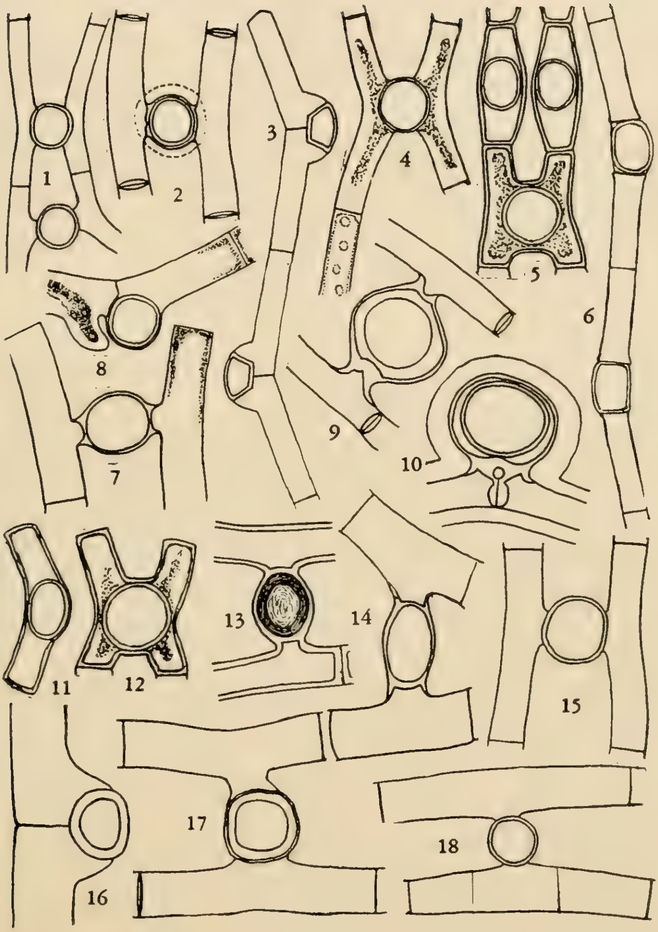
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PLATE XV

Mougeotia

Fig. 1.—*M. caelestis,* zygospore and two aplanospores with local thickening of sporangial walls, from Miami, Oklahoma. Figs. 2–3.—*M. nummuloides,* three aplanosporangia with characteristic bend where the spore is formed, and a zygospore and gametangia, from Burgaw, North Carolina. Fig. 4.—*M. sinensis,* two zygospores with reticulate median spore wall, from Tinghai, China. After Li. Fig. 5.—*M. megaspora,* zygospore and gametangia, from Sweden. After Wittrock. Figs. 6–7.—*M. ornata,* zygospores and detail of spore walls, from Szechwan, China. After Jao. Fig. 8.—*M. micropora,* zygospore and gametangia, from Oklahoma. Figs. 9–11.—*M. areolata,* aplanospore, zygospore, and details of spore wall, from Oveida Springs, Florida. Fig. 12.—*M. sumatrana,* zygospore and gametangia, from Sumatra. After Schmidle. Fig. 13.—*M. talyschensis,* zygospores and gametangia, from Baku, U.S.S.R. After Woronichin. Fig. 14.—*M. gotlandica,* zygospore with characteristic spore markings, from Sweden. After Wittrock. Figs. 15–16.—*M. globulispora,* zygospore and details of spore wall, from Szechwan, China. After Jao. Fig. 17.—*M. laevis,* zygospore and gametangia, from England. After Archer. Figs. 18–19.—*M. lamellosa,* zygospore, gametangia, and spore wall details, from Szechwan, China. After Jao. Fig. 20.—*M. microverrucosa,* zygospores and gametangia from Germany. After Krieger.


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PLATE XVI

Mougeotia

Fig. 1.—*M. pulchella,* vegetative cell and zygospores from Douglas Lake, Michigan. Figs. 2–4.—*M. robusta,* vegetative cells, zygospores, and gametangia from Winchester, Massachusetts. A cell in which the chromatophore has divided completely with the nucleus between the halves is represented in Fig. 4. One not infrequently finds chromatophores of this and a few other species with ends cleft to various depths. Fig. 5.—*M. daytonae,* zygospore and gametangia from Daytona, Florida. Fig. 6.—*M. handelii,* zygospore, gametangia, and vegetative cell from Yünnanfu, China. After Skuja. Fig. 7.—*M. sanfordiana,* from Daytona, Florida. Fig. 8.—*M. oblongata,* a pair of zygospores with attached gametangia from Fort Myers, Florida. Figs. 9–11.—*M. laetevirens,* two forms of zygospore and an aplanospore from Long Island, New York. Fig. 12.—*M. varians,* zygospore from Sweden. After Wittrock. Figs. 13–15.—*M. opelousensis,* three zygospores seen at different angles, from Opelousas, Louisiana. After Taft. Fig. 16.—*M. angolensis,* zygospore from Angola, Africa. After West. Fig. 17.—*M. gelatinosa,* zygospore with pectic sporangium wall from Sweden. After Wittrock.

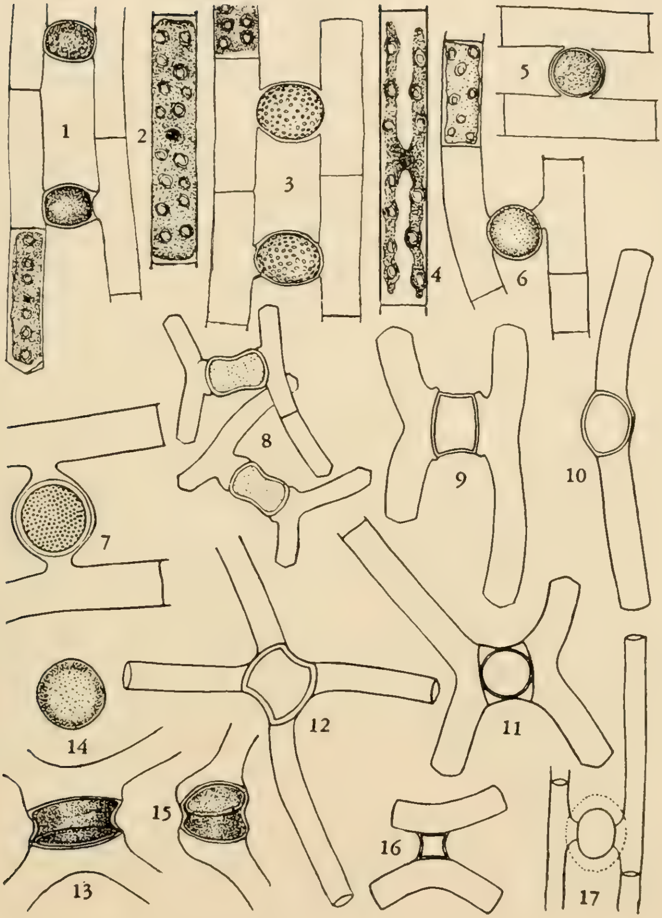
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PLATE XVII

Mougeotia

Fig. 1.—*M. depressa,* zygospore and gametangia from Germany. After Kützing. Figs. 2–3.—*M. ovalis,* gametangia and zygospore, and details of spore wall. After Wittrock and Nordstedt. Figs. 4–6.—*M. pectosa,* zygospore and aplanospores from Fort Myers, Florida. Figs. 7–8.—*M. disjuncta,* zygospores, one with change of sporangium wall to pectic compound, the other without. Specimens from Fort Myers, Florida. Figs. 9–10.—*M. oedogonioides,* zygospores resulting from lateral and scalariform conjugation. Note unique remnants of conjugating tubes. Figs. 11–12.—*M. operculata,* gametangia, zygospore, and details of spore wall from Florida. Figs. 13–14.—*M. atubulosa,* zygospores in pectic-walled sporangia, and details of spore wall from Java. After Krieger. Figs. 15–17.—*M. cyanea,* zygospores, and aplanospore, and details of spore wall from Michigan. Fig. 18.—*M. caimani,* part of group of interconjugating filaments from Haiti. Figs. 19–20.—*M. transeaui,* two forms of zygospores and an aplanospore from Illinois. Fig. 21.—*M. poinciana,* zygospores and an aplanospore from Fort Myers, Florida. Differs from the preceding only in having larger dimensions. Fig. 22.—*M. seminoleana,* zygospore and aplanospore from Fort Myers, Florida. Fig. 23.—*M. cherokeana,* zygospores and arching gametangia from Oklahoma. Figs. 24–25.—*M. pawhuskae,* gametangia and zygospores, and spore wall details from Oklahoma.

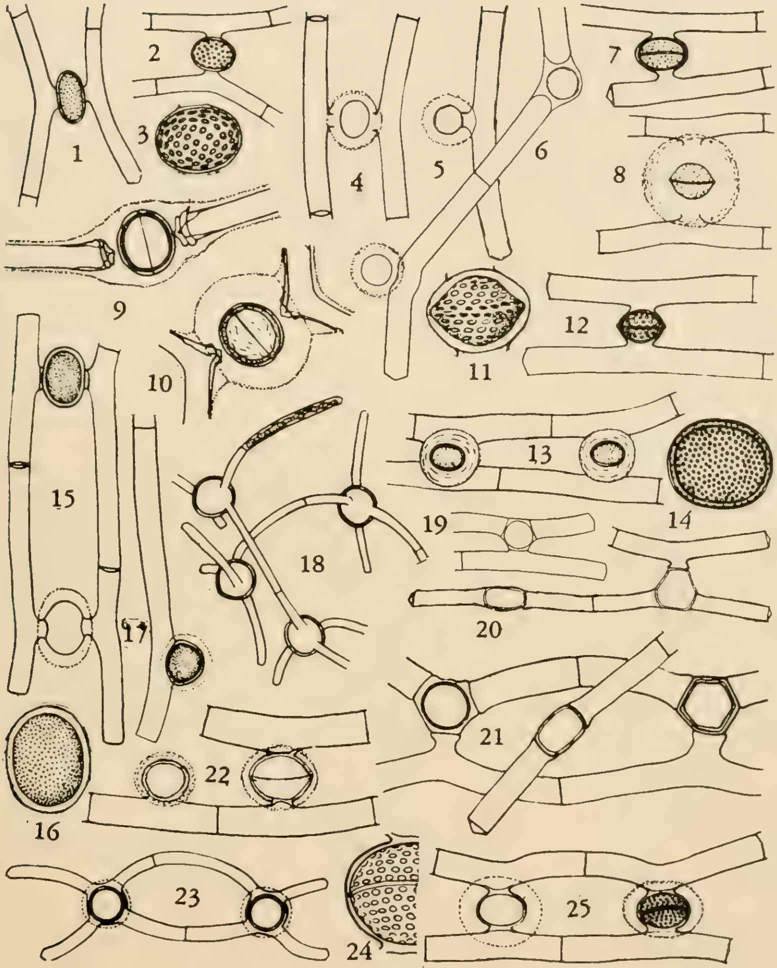
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PLATE XVIII

Mougeotia

Figs. 1–3.—*M. americana,* zygospores and gametangia, and an aplanospore with its relatively long sporogenous cell from Oneida Lake, New York. Figs. 4–5.—*M. corniculata,* zygospore and vegetative cell from Bohemia. Modified from figure by Hansgirg. Figs. 6–8.—*M. thylespora,* zygospores and gametangia from Estonia. After Skuja. In Fig. 6 are aplanospores from Florida where zygospores were found with them. Figs. 9–10.—*M. uberosperma,* vegetative cell, aplanospore, and zygospore from Kentani, South Africa. Figs. 11–14.—*M. craterophora,* four zygospores from the Azores. After Bohlin. Figs. 15–16.—*M. irregularis,* two zygospores from Angola, Africa. After West. Fig. 17.—*M. delicata,* zygospore and gametangia from Austria. After Beck. Figs. 18–20.—*M. granulosa,* vegetative cell, parthenospore, and two zygospores from Cape Town, South Africa. Figs. 21–22.—*M. elegantula,* zygospores and an aplanospore. Fig. 21 after Wittrock. Figs. 23–25.—*M. boodlei,* two aplanospores and the very rare zygospore, from Charleston, Illinois. Figs. 26–31.—*M. capucina,* vegetative cell, zygospores, an aplanospore, and a parthenospore. The last figure shows scalariform conjugation between two adjacent cells, from Tupper Lake, New York.

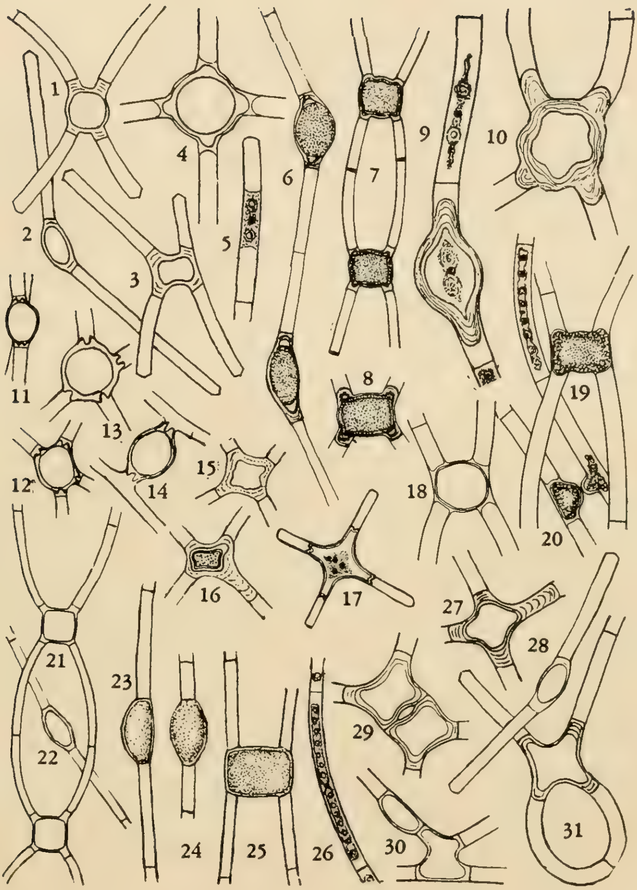
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PLATE XIX

Mougeotia

Figs. 1–2.—*M. gracillima,* aplanospore and zygospore from Oneida Lake, New York. Figs. 3–4.—*M. viridis,* aplanospore and zygospore from Saugatuck, Michigan. Figs. 5–6.—*M. producta,* aplanospore and zygospore from Burma. After West. Figs. 7–8.—*M. regellii,* zygospores, face and lateral views from Greece. After Skuja. Figs. 9–10.—*M. tumidula,* zygospore, aplanospore, and vegetative cell from Illinois. Figs. 11–12.—*M. austriaca,* two zygospores from Wiener-Neustadt, Austria. After Czurda. Figs. 13–14.—*M. rotundangulata,* zygospore and details of spore wall from Szechwan, China. After Jao. Fig. 15.—*M. punctata,* zygospore from Sweden. After Wittrock. Fig. 16.—*M. virescens,* zygospore from England. After Hassall. Figs. 17–18.—*M. paludosa,* two zygospores from England. After West. Figs. 19–20.—*M. quadrangulata,* aplanospore and zygospore from Illinois. Fig. 21.—*M. tropica,* aplanospore (in optical section) and a vegetative cell from Angola, Africa. After West. Figs. 22–23.—*M. miamiana,* two forms of aplanospores from the same filament, from Miami, Oklahoma. Fig. 24.—*M. ventricosa,* aplanospores from Sweden. After Wittrock. Fig. 25.—*M. rava,* aplanospores variously placed in the sporogenous cell, from Starkville, Mississippi. Figs. 26–28.—*M. prona,* vegetative cell, early stage of aplanospore formation, and mature aplanospores from High Hill, Long Island, New York. Fig. 29.—*M. mayori,* an aplanospore from Colombia, South America. After West. Figs. 30–31.—*M. tenerrima,* vegetative cell and aplanospore from Colombia, South America. After West. Fig. 32.—*M. subpaludosa,* zygospore from Kwangtung, China. After Ley.

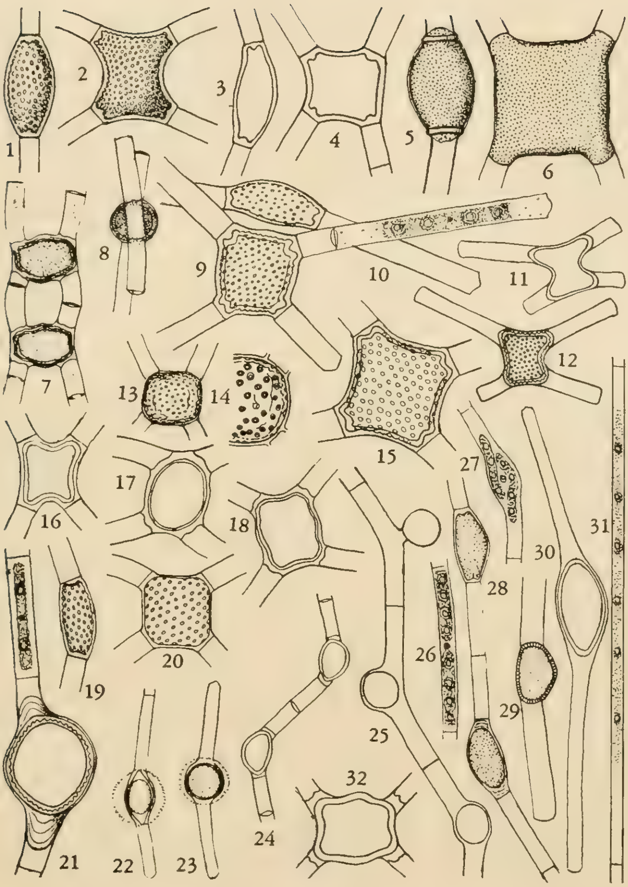
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PLATE XX

Temnogametum, Sirocladium, and Entransia

Figs. 1–4.—*Temnogametum uleanum*, vegetative cells and gametangia, zygospores formed by scalariform and lateral conjugation, from Brazil. After Möbius. Figs. 5–6.—*T. transeaui*, mature zygospores formed by scalariform and lateral conjugation; early stages similar to the preceding species, from Ecuador. After Prescott. Figs. 7–9.—*T. thaxteri*, vegetative cell, two gametangia, zygospore, and aplanospore from Trinidad, British West Indies. Fig. 10.—*T. heterosporum*, vegetative cell, lateral and scalariform conjugation from Angola. After West. Figs. 11–14.—*Sirocladium kumaoënse*, vegetative cells, three aplanospores, a parthenospore (Fig. 13), and a zygospore and gametangia from northern India. Drawn from type specimens. Fig. 15.—*Entransia fimbriata*, vegetative cells with characteristic parietal chromatophores with nucleus between, from Nova Scotia. After Hughes.

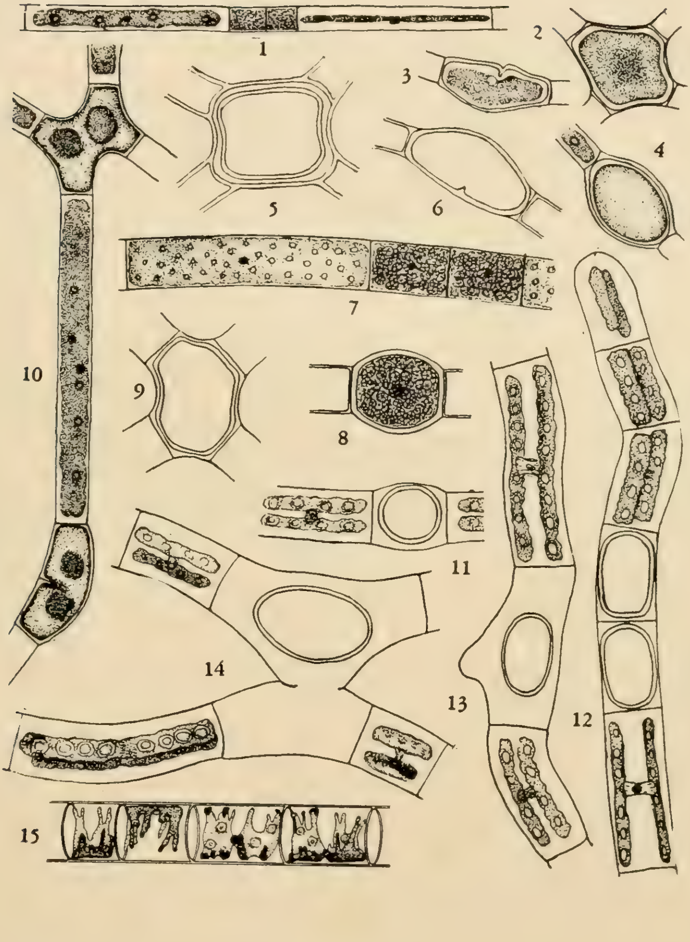
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PLATE XXI

Spirogyra

Fig. 1.—*S. communis,* gametangia and zygospores from Illinois. Fig. 2.—*S. intorta,* conjugating filaments and zygospores from Szechwan, China. After Jao. Fig. 3.—*S. juergensii,* typical gametangia and zygospores from Illinois. Fig. 4.—*S. singularis,* gametangia and zygospores from Illinois. Fig. 5.—*S. gracilis,* gametangia and zygospores from Ohio. Fig. 6.—*S. fragilis,* gametangia and zygospores. Note separation of receptive gametangia following conjugation, from Szechwan. After Jao. Fig. 7.—*S. silvicola,* gametangia and zygospores from northern Illinois. After Britton. Fig. 8.—*S. teodoresci,* gametangia and zygospores from Illinois. Figs. 9–10.—*S. variformis,* vegetative cell, gametangia, and zygospores variously deformed by the gametangial walls from Cape Town, South Africa. Fig. 11.—*S. condensata,* lateral and scalariform conjugation, vegetative cell, and zygospores from Charleston, Illinois. Figs. 12–14.—*S. pseudovarians,* gametangia, zygospores, and optical section of spore wall from Czechoslovakia. After Czurda.

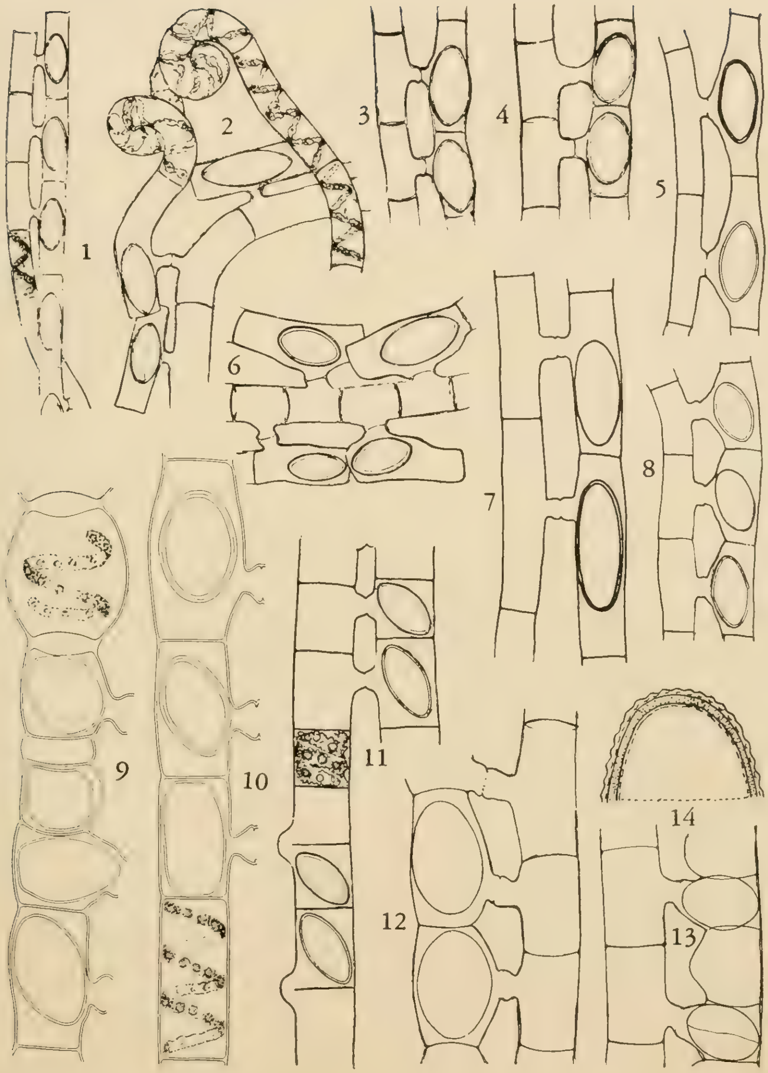
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PLATE XXII

Spirogyra

Fig. 1.—*S. varians,* gametangia, zygospores, and inflated sterile cell from central Illinois. Fig. 2.—*S. bicalyptrata,* gametangia and zygospores from Czechoslovakia. After Czurda. Fig. 3.—*S. circumlineata,* gametangia, zygospores, and sterile cell from central Illinois. Fig. 4.—*S. fennica,* lateral and scalariform conjugation, and zygospores from Szechwan, China. After Jao. Figs. 5–6.—*S. parvula,* scalariform and lateral conjugation, and an aplanospore from central Illinois. Fig. 7.—*S. supervarians,* gametangia and zygospores from Cape Town, South Africa. Fig. 8.—*S. borgeana,* gametangia and zygospores from Illinois. (See also Fig. 16, Pl. XXIII.) Fig. 9.—*S. subsalina,* gametangia and zygospore from Finland. Figs. 10–11.—*S. gibberosa,* lateral and scalariform conjugation, separation of receptive gametangia, and zygospores from Szechwan. After Jao. Fig. 12.—*S. catenaeformis,* scalariform and lateral conjugation, and sterile cell from central Illinois. (See also Fig. 16, Pl. XXIV.) Fig. 13.—*S. bullata,* zygospores, gametangia, and sterile cells from Szechwan. After Jao. Figs. 14–18.—*S. pratensis,* vegetative cells, aplanospores, and zygospores. Note growth of cells during development of aplanosporangia of which there are two extreme types, also the bullate type of sterile cells. Type material from Charleston, Illinois.

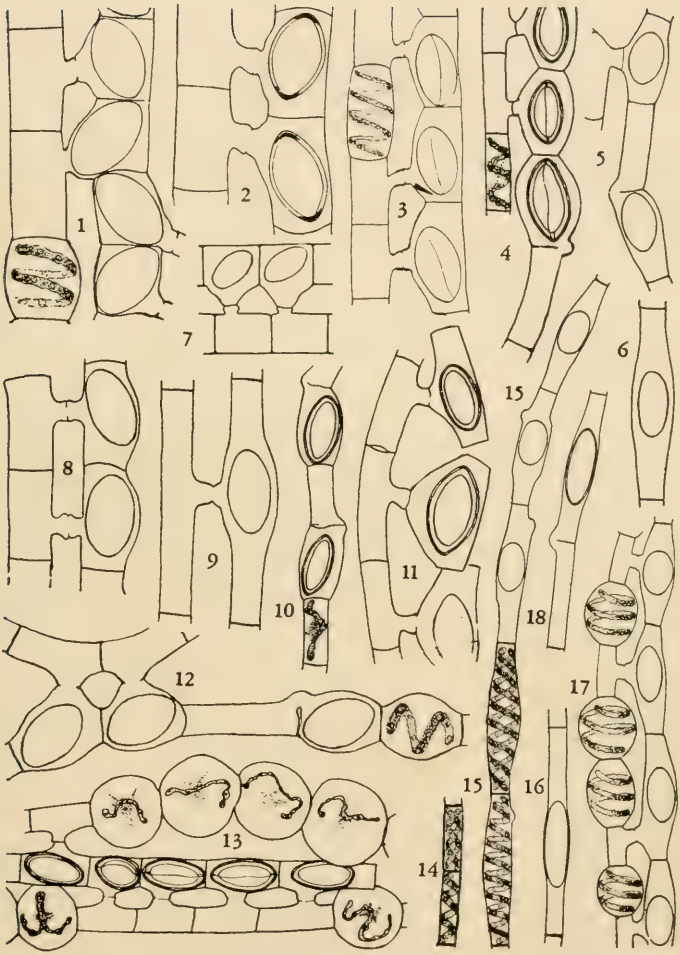
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PLATE XXIII

Spirogyra

Fig. 1.—*S. flavescens,* zygospores and gametangia from Michigan. Fig. 2.—*S. subsalsa,* gametangia and zygospore from Florida. Fig. 3.—*S. paludosa,* gametangia and zygospores from Bohemia. After Czurda. Fig. 4.—*S. mirabilis,* zygospore (very rare) and aplanospore (the usual method of reproduction) from Douglas Lake, Michigan. Fig. 5.—*S. longata,* zygospores and gametangia from China. After Jao. The spores are not always so long but are always ovoid. Fig. 6.—*S. oltmannsii,* aplanospores and sporangia from South Africa. After Huber-Pestalozzi. Spores are "possibly scrobiculate" when mature. Fig. 7.—*S. suecica,* gametangia and zygospores from Sweden. After Borge. Fig. 8.—*S. gallica,* gametangia and zygospores from France. After Petit. Fig. 9.—*S. porticalis,* zygospores and gametangia from Illinois. Fig. 10.—*S. lacustris,* gametangia, zygospore, and conjugating tubes from Austria. Figs. 11–13.—*S. lutetiana,* various forms of zygospores from France. After Petit. Figs. 14–15.—*S. polymorpha,* zygospores, parthenospores, and variously shaped gametangia from China. After Jao. Fig. 16.—*S. borgeana,* a remarkably rare instance of conjugation through end walls of two filaments with two adjoining receptive gametangia of another filament. Figs. 17–18.—*S. aplanospora,* lateral conjugation and aplanospore formation from India. After Randhawa.

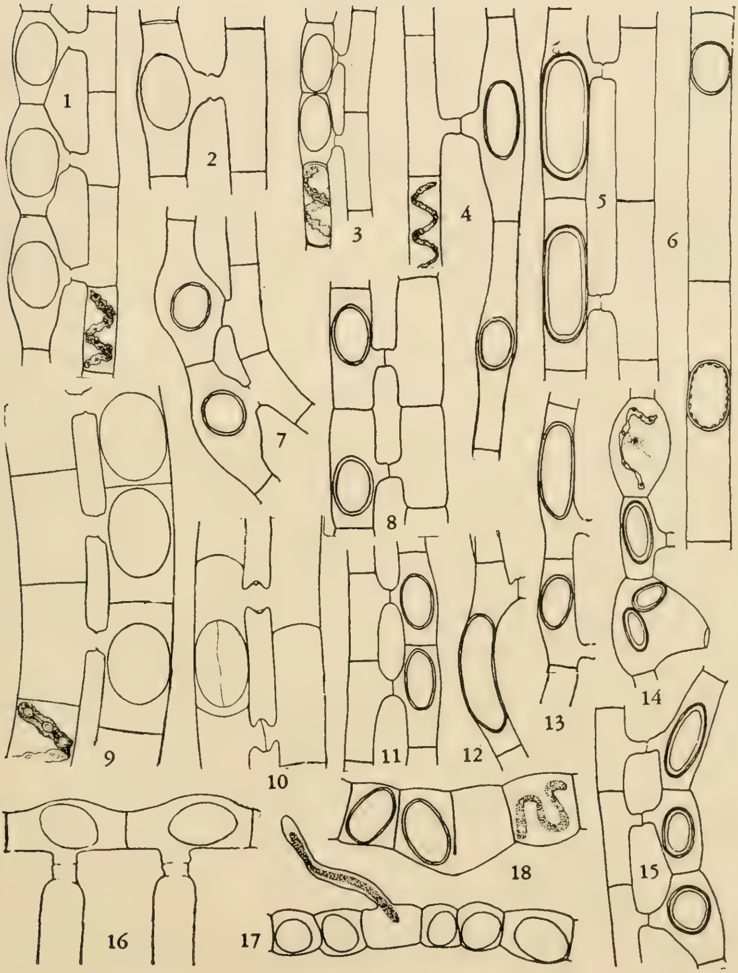
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PLATE XXIV

Spirogyra

Fig. 1.—*S. velata*, spore wall pattern. After Jao. Fig. 2.—*S. occidentalis*, gametangia and zygospores from Illinois. Fig. 3.—*S. luteospora*, zygospore and receptive gametangium from Bohemia. After Czurda. Fig. 4.—*S. sulcata*, zygospores and gametangia from Wisconsin. After Blum. Fig. 5.—*S. obovata*, gametangia and zygospores from Szechwan, China. After Jao. Fig. 6.—*S. asiatica*, zygospore from Tibet. After Czurda. Fig. 7.—*S. lagerheimii*, lateral conjugation and zygospore from Sweden. After Wittrock. Fig. 8.—*S. taftiana*, gametangia, zygospore, and sterile cells from Texas. After Taft. Fig. 9.—*S. perforans*, gametangia and zygospores from Florida. Fig. 10.—*S. minutifossa*, zygospore and gametangia from Massachusetts. After Jao. Fig. 11.—*S. porangabae*, gametangia, zygospores, and sterile cells from northern Brazil. Fig. 12.—*S. skujae*, gametangia and zygospores from India. After Randhawa. Fig. 13.—*S. hoehnei*, gametangia and zygospore from Kentucky. Figs. 14–15.—*S. robusta*, gametangia and zygospores from South Africa. After Nygaard. Fig. 16.—*S. catenaeformis*, a not uncommon form of a laterally conjugating filament from Illinois. Fig. 17.—*S. scrobiculata*, unusual form of receptive gametangia and conjugation through end wall of filament from Illinois.

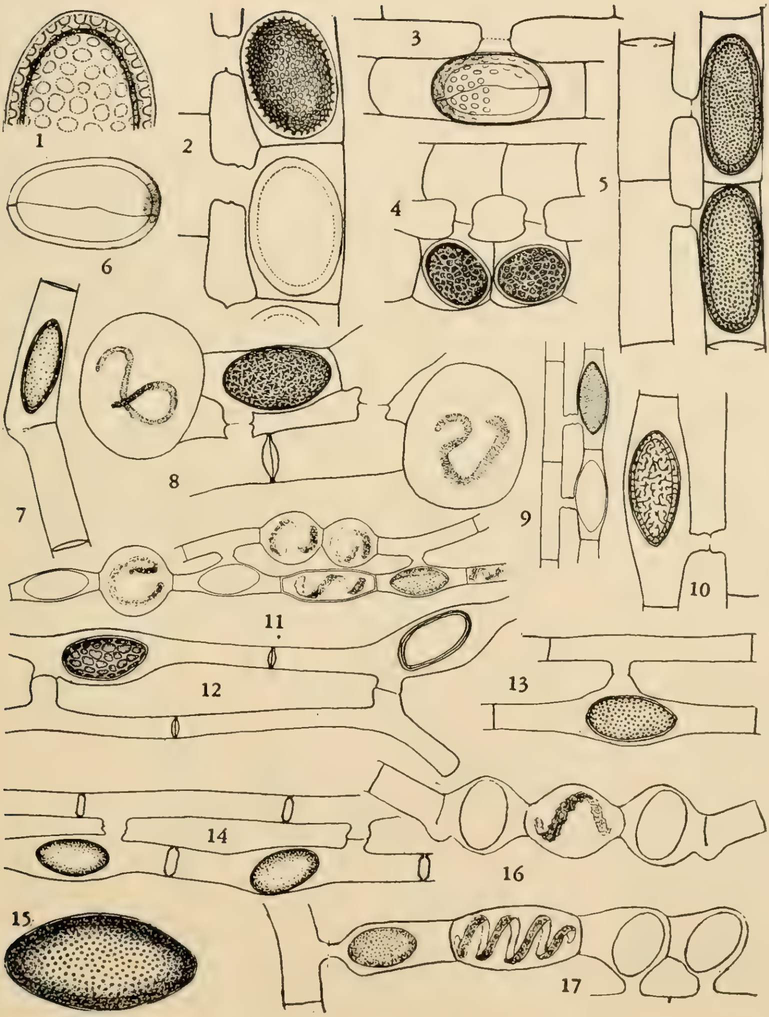
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PLATE XXV

Spirogyra

Figs. 1–2.—*S. subpapulata,* zygospores, aplanospores, and sterile cells from Szechwan, China. After Jao. Figs. 3–5.—*S. papulata,* scalariform and lateral conjugation, zygospores, and spore wall pattern from Szechwan. After Jao. Figs. 6–7.—*S. scrobiculata,* scalariform conjugation, zygospores, and details of spore wall from Austria. After Czurda. Fig. 8.—*S. aphanosculpta,* scalariform conjugation and zygospores from Greece. After Skuja. Figs. 9–10.—*S. daedalea,* scalariform conjugation, zygospores, and spore wall pattern, from Yugoslavia. After Czurda. Fig. 11.—*S. kaffirita,* zygospores and gametangia from South Africa. Fig. 12.—*S. ghosei,* gametangia and mature zygospores from India. After Singh. Figs. 13–15.—*S. daedaleoides,* vegetative cell, lateral and scalariform conjugation, and zygospores from Latvia. After Skuja.

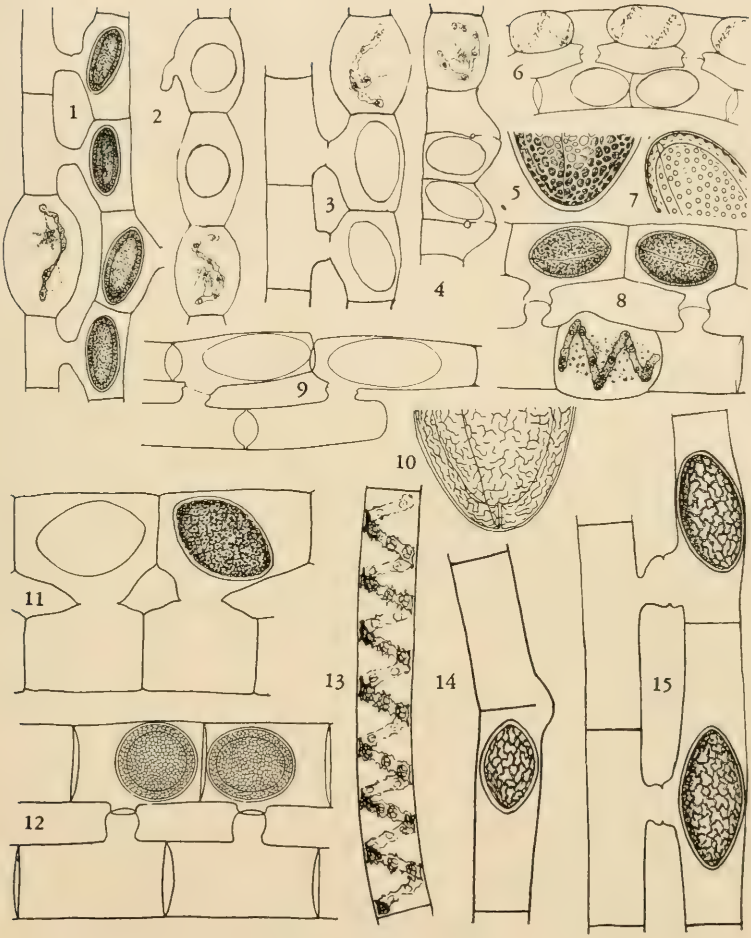
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PLATE XXVI

Spirogyra

Figs. 1–2.—*S. maravillosa*, vegetative cell and aplanospores from northern Brazil. Fig. 3.—*S. irregularis*, gametangia and zygospores from Illinois. Fig. 4.—*S. fuellebornei*, gametangia and zygospores from Nyassa Lake region, Africa. After Schmidle. Fig. 5.—*S. microspora*, zygospores resulting from lateral conjugation, from Szechwan, China. After Jao. Figs. 6–7.—*S. hollandiae*, gametangia and zygospores from New Guinea. After Taft. Fig. 8.—*S. rivularis*, gametangia and zygospores from Kansas. Figs. 9–10.—*S. biformis*, lateral and scalariform conjugation and zygospores from China. After Jao. Figs. 11–12.—*S. hyalina*, lateral and scalariform conjugation, and resulting zygospores, also a parthenospore from Mississippi. Figs. 13–14.—*S. pseudoneglecta*, lateral and scalariform conjugation, and zygospores from Moravia. After Czurda. Fig. 15.—*S. columbiana*, gametangia and zygospore from Colombia, South America. After Czurda. Fig. 16.—*S. parvispora*, gametangia and zygospores from Florida. After Wood. Fig. 17.—*S. turfosa*, gametangia, zygospore, and vegetative cell from Spain. After Gay.

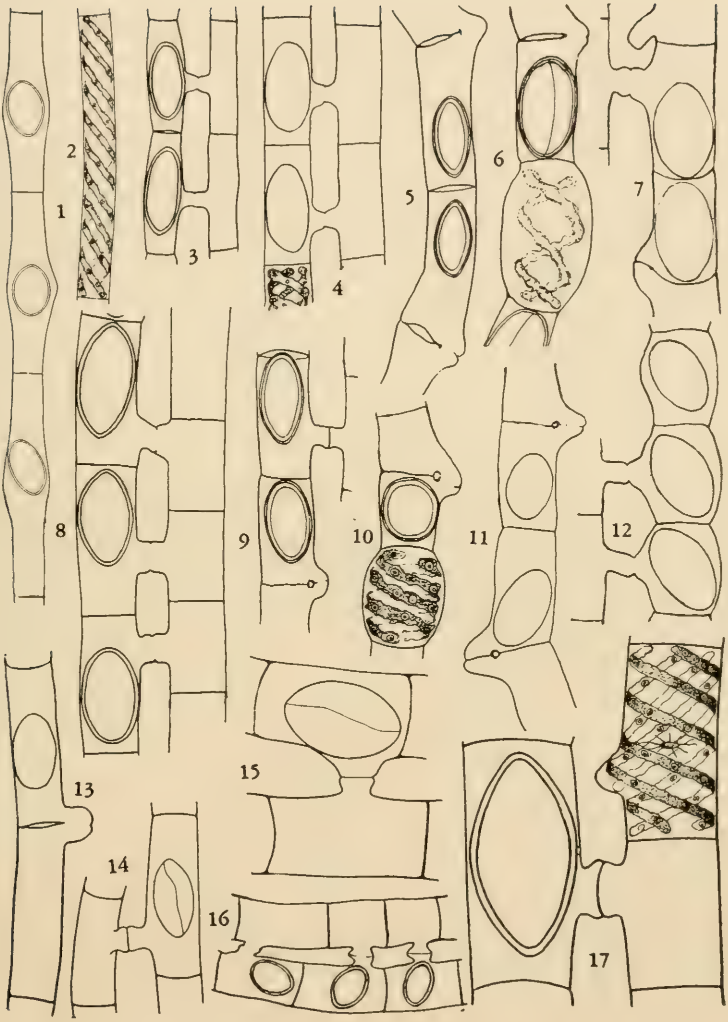
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PLATE XXVII

SPIROGYRA

FIGS. 1–2.—*S. nitida,* gametangia and zygospores from Szechwan, China. After Jao. FIG. 3.—*S. hymerae*, vegetative cell, zygospore, and gametangia from Indiana. After Britton. FIGS. 4–5.—*S. setiformis,* gametangia and zygospore from Charleston, Illinois. FIG. 6.—*S. elliptica,* zygospore and gametangia from Szechwan, China. After Jao. FIGS. 7–8.—*S. wrightiana,* vegetative cell, aplanospores, and sporangia from Parahiba, Brazil. FIG. 9.—*S. yunnanensis,* zygospores and gametangia from Yünnan, China. After L. C. Li. FIG. 10.—*S. hatillensis,* zygospores and gametangia from Puerto Rico. FIG. 11.—*S. ellipsospora,* zygospore and vegetative cell from Illinois. FIG. 12.—*S. emilianensis,* zygospores and gametangia from Massachusetts. FIG. 13.—*S. exilis,* gametangia, zygospores, and sterile cell from Burma. After West. FIGS. 14–15.—*S. neglecta,* zygospores and gametangia. Modified after Czurda. FIG. 16.—*S. decimina,* zygospores and gametangia. After Jao. FIG. 17.—*S. splendida,* zygospore and gametangium. After G. S. West.

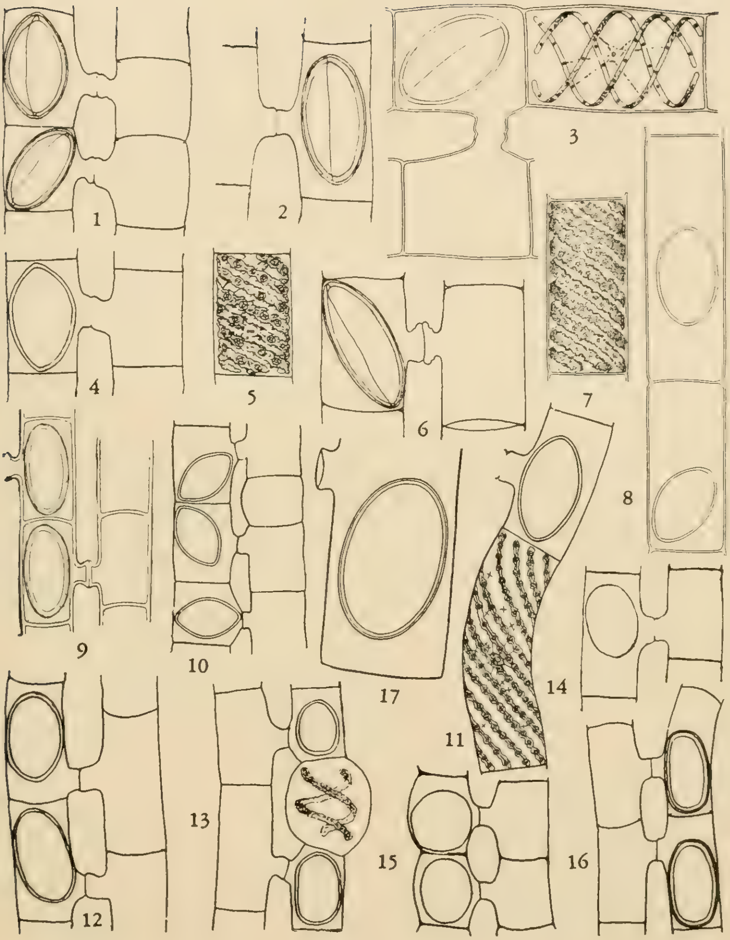
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PLATE XXVIII

Spirogyra

Figs. 1–2.—*S. plena,* receptive gametangia and zygospores formed by lateral and scalariform conjugation from Burma. After West. Fig. 3.—*S. szechwanensis,* gametangia and zygospore from Chungking, China. After Jao. Fig. 4.—*S. jugalis,* receptive gametangium and zygospore from Illinois. Fig. 5.—*S. margaritata,* receptive gametangium and zygospore from specimens collected at Dresden, Germany. Fig. 6.—*S. bichromatophora,* gametangia and zygospores from India. After Randhawa. Fig. 7.—*S. baileyi,* gametangia and zygospores from Australia. After Schmidle. Fig. 8.—*S. dubia,* gametangia and zygospores. After Kützing. Fig. 9.—*S. puncticulata,* zygospores and gametangia from Massachusetts. After Jao. Fig. 10.—*S. aequinoctialis,* zygospore and gametangia from central Africa. After West. Figs. 11–13.—*S. rhizopus,* zygospores, gametangia, holdfast, and details of spore wall, from Peiping, China. After Jao. Fig. 14.—*S. dictyospora,* vegetative cell, gametangia, and zygospores from Chungking, China. After Jao. Figs. 15–16.—*S. fossa,* gametangia, zygospore, and spore wall details from Massachusetts. After Jao. Figs. 17–18.—*S. smithii,* gametangia, zygospores, and details of outer and inner layers of median spore wall. Figs. 19–20.—*S. schmidtii,* zygospores and gametangia from Koh Chang, Siam. After West.

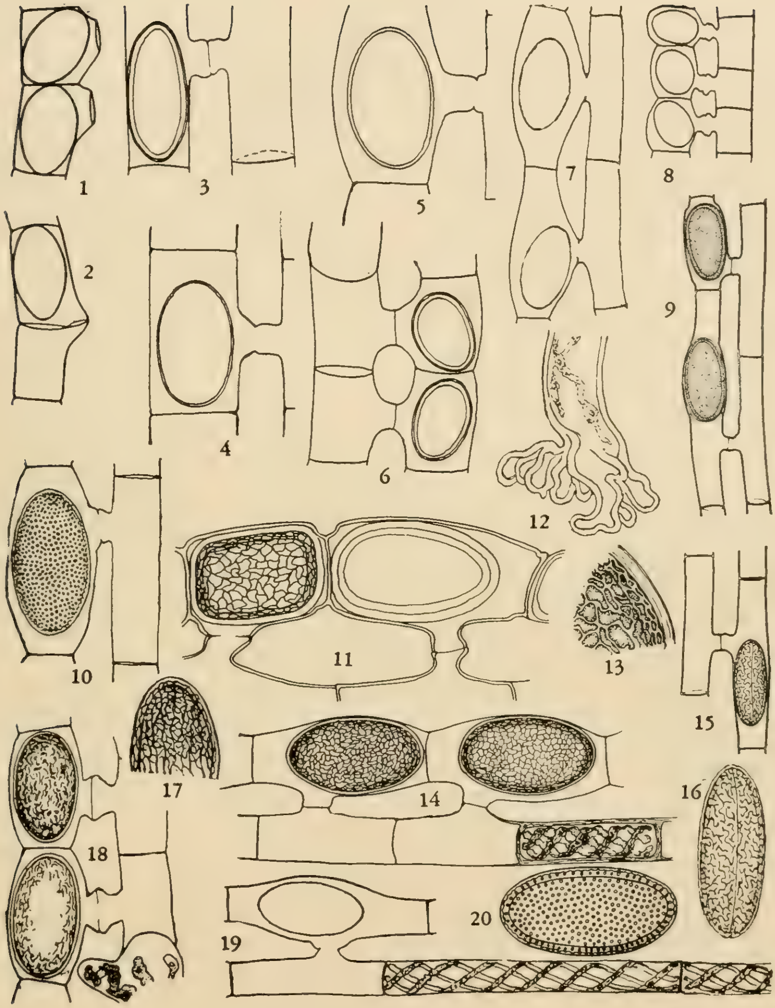
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PLATE XXIX

Spirogyra

Figs. 1–2.—*S. chungkingensis,* gametangia, zygospores, and details of spore wall. After Jao. Fig. 3.—*S. orientalis,* receptive gametangium and zygospore from Burma. After West. Figs. 4–5.—*S. subcylindrospora,* gametangia, zygospore, and spore wall pattern, from Szechwan, China. After Jao. Fig. 6.—*S. mienningensis,* zygospore and gametangia from Yünnan, China. After Li. Fig. 7.—*S. shantungensis,* zygospore and gametangia from China. After Li. Figs. 8–9.—*S. pulchrifigurata,* gametangia, zygospores, and spore wall details from Szechwan. After Jao. Fig. 10.—*S. torta,* gametangia and zygospores from Massachusetts. After Blum. Figs. 11–13.—*S. quadrilaminata,* zygospore, optical section of spore wall, and spore wall pattern, from Szechwan. After Jao. Figs. 14–16.—*S. rhizobrachialis,* gametangia, zygospore, rhizoid, and spore wall pattern, from Chungking, China. After Jao. Figs. 17–18.—*S. paraguayensis,* zygospores and spore wall pattern from South America. After Borge. Figs. 19–21.—*S. subreticulata,* zygospore, optical section of spore wall, and spore wall pattern, from South Africa. After Fritsch.

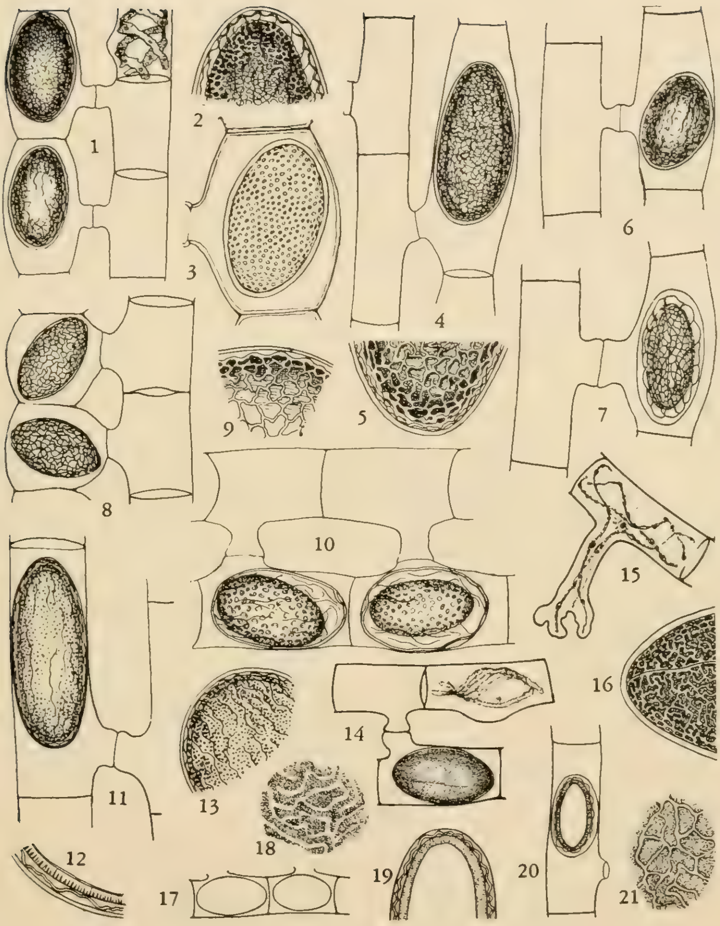
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PLATE XXX

Spirogyra

Figs. 1–2.—*S. brunnea,* gametangia, zygospores, and spore wall pattern, from Transvaal. After Fritsch and Rich. Figs. 3–4.—*S. scripta,* gametangia, and zygospores from Transvaal. After Nygaard. Fig. 5.—*S. fluviatilis,* receptive gametangium and zygospore from Illinois. Fig. 6.—*S. grossii,* zygospore from Yugoslavia. After Schmidle. Fig. 7.—*S. novae-angliae,* gametangia and zygospore from New York. After Blum. Figs. 8–10.—*S. verruculosa,* vegetative cell, zygospore, and spore wall pattern from Hangchow, China. After Jao. Figs. 11–13.—*S. punctulata,* vegetative cell, gametangia, zygospore, and cell wall details, from China. After Jao. Figs. 14–16.—*S. malmeana,* gametangia, zygospores, and spore wall pattern from Brazil. After Borge. Figs. 17–18.—*S. echinospora,* chromatophores, gametangia, zygospore, and median spore wall pattern from New Hampshire. After Blum. Figs. 19–20.—*S. diluta,* conjugating filaments, and characteristic orientation of spores, also spore wall details. In part after Wood.

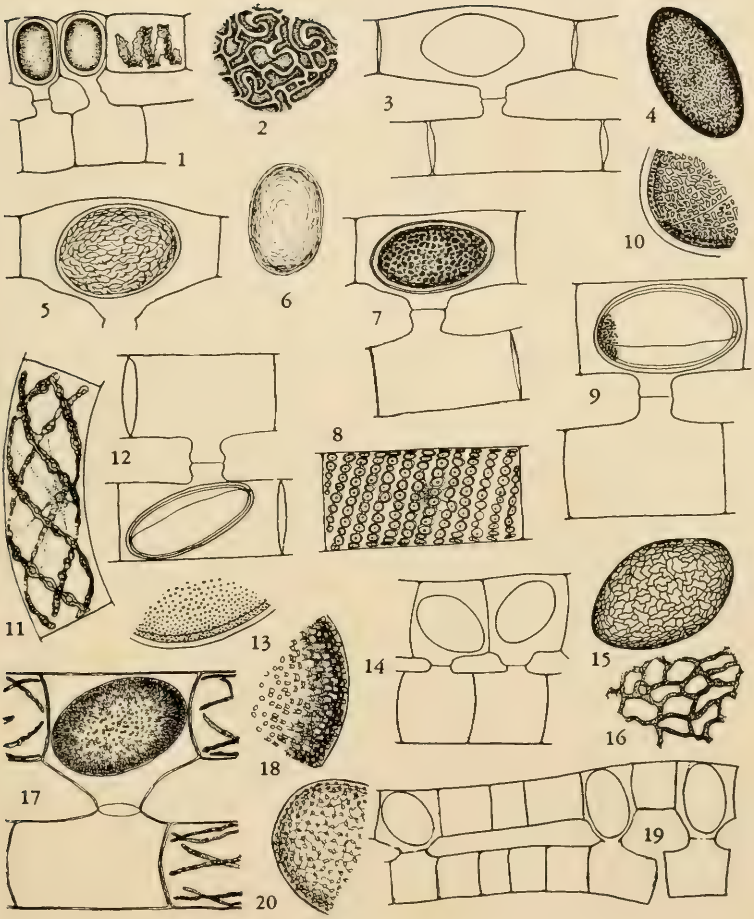
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PLATE XXXI

Spirogyra

Figs. 1–2.—*S. echinata,* zygospores, gametangia, and details of spore wall from Montgomery, Iowa. After Blum. Figs. 3–5.—*S. reinhardii,* vegetative cell, gametangia, and spore wall patterns, from Brazil. After Borge. Fig. 6.—*S. hunanensis,* chromatophores, gametangia, and zygospore from China. After Jao. Fig. 7.—*S. discoidea,* vegetative cell, gametangia, and zygospores from Cape Town, South Africa. Fig. 8.—*S. pellucida,* gametangia, and two views of zygospore from England. After West. Fig. 9.—*S. sphaerospora,* gametangia, conjugating tubes, and zygospores from Finland. After Hirn. Fig. 10.—*S. sinensis,* gametangia and zygospore from Hangchow, China. After L. C. Li. Figs. 11–13.—*S. colligata,* twisted filament, end walls of cells, gametangia, and zygospores from England. After Hodgetts. Figs. 14–15.—*S. majuscula,* zygospores and an aplanospore from Illinois. Fig. 16.—*S. glabra,* gametangia and zygospores from Vienna, Austria. After Czurda. Figs. 17–18.—*S. bellis,* gametangia, zygospore, and spore wall details. After Czurda.

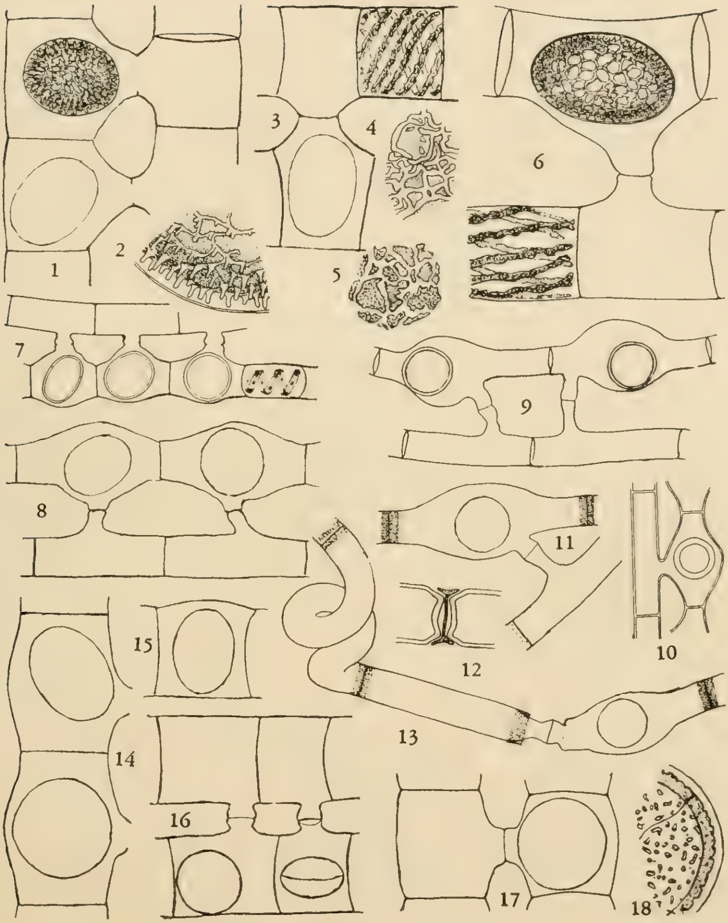
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PLATE XXXII

Spirogyra

Figs. 1–3.—*S. oblata*, vegetative cell, gametangia, zygospores, and details of spore wall structure from Hangchow, China. After Jao. Fig. 4.—*S. formosa*, zygospores and receptive gametangia from Illinois. Fig. 5.—*S. jassiensis*, lateral conjugation and zygospores from Bessarabia. After Teodoresco. Fig. 6.—*S. crassa*, receptive gametangia and zygospores from France. After Petit. Fig. 7.—*S. manoramae*, gametangia and zygospores from India. After Randhawa. Figs. 8–9.—*S. jatobae*, receptive gametangia, zygospores, and vegetative cell from Brazil. Figs. 10–11.—*S. maxima*, zygospores and spore wall pattern from South America. After Borge. Figs. 12–13.—*S. heeriana*, gametangia and zygospores, also spore wall pattern, from Vienna, Austria. After Czurda. Figs. 14–15.—*S. lenticularis*, receptive gametangia, zygospores seen from different angles, and spore wall pattern, from Cape Town, South Africa.

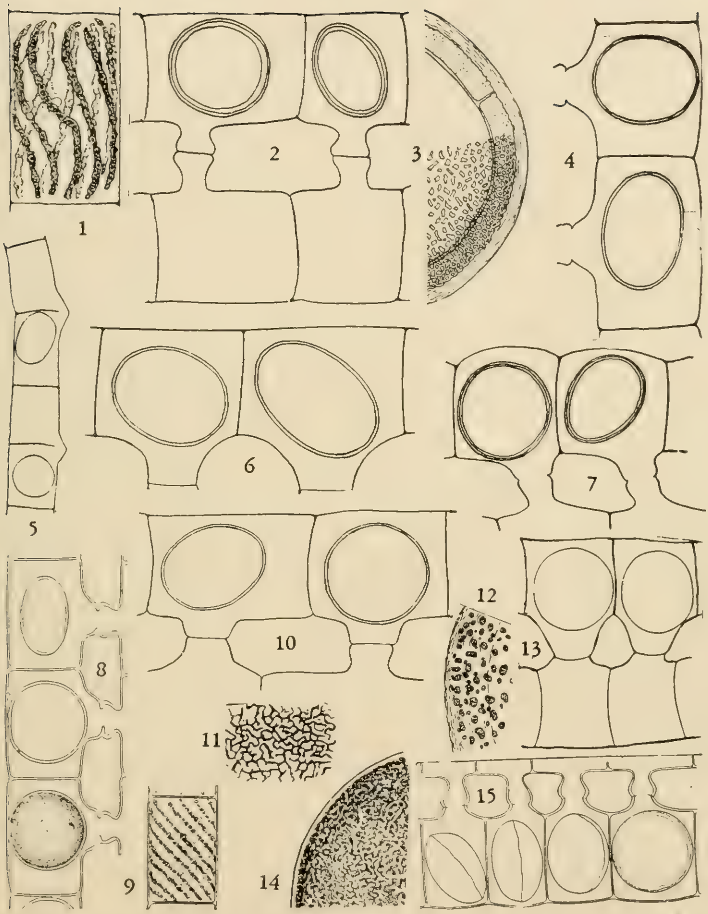
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PLATE XXXIII

Spirogyra

Fig. 1.—*S. crassoidea,* two views of zygospore from Illinois. Figs. 2–4. —*S. hydrodictya,* zygospores and gametangia after scalariform conjugation; early stage in lateral conjugation. Note unusual thickness of the tube walls. Specimen from Coffeen, Illinois. Fig. 5.—*S. texensis,* gametangia and zygospore from Karnac, Texas. After Taft. Fig. 6.—*S. lushanensis,* zygospores and gametangia from China. After Li. Figs. 7–8.—*S. sirogonioides,* scalariform and lateral conjugation with resulting zygospores from Charleston, Nova Scotia. After Hughes. Fig. 9.—*S. taylorii,* gametangia and zygospores from Massachusetts. After Jao. Figs. 10–11.—*S. liana,* lateral and scalariform conjugation and zygospores from China. Figs. 12–13.—*S. collinsii,* zygospores formed by lateral and scalariform conjugation from Mississippi. Fig. 14.—*S. chenii,* lateral and scalariform conjugation, zygospores, and sterile cell from Szechwan, China. After Jao.

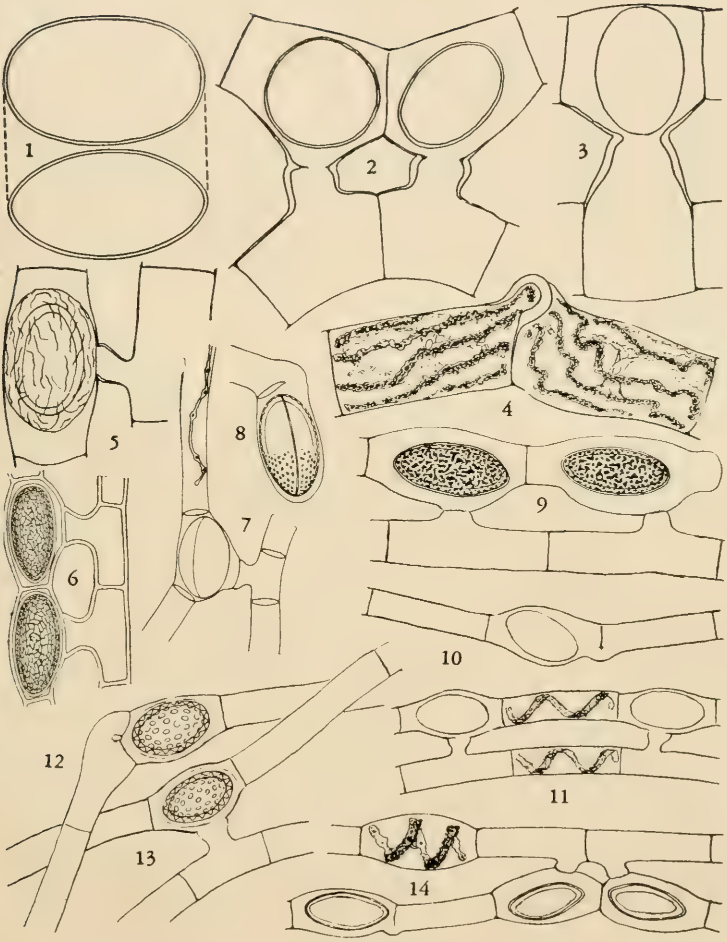
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PLATE XXXIV

Spirogyra

Fig. 1.—*S. punctata,* vegetative cells, gametangia, and zygospores from China. After Jao. Figs. 2–3.—*S. esthonica,* conjugating filaments and median spore wall, from Estonia. After Skuja. Fig. 4.—*S. suomiana,* zygospore and gametangia from Finland. After Hirn. Figs. 5–6.—*S. punctiformis,* vegetative cells, zygospores, and spore wall details from Illinois. Figs. 7–8.—*S. reflexa,* gametangia and zygospores from Illinois. The lower figure illustrates an example of "cross conjugation." Fig. 9.—*S. micropunctata,* zygospores and gametangia from Illinois. Figs. 10–11.—*S. corrugata,* vegetative cell, conjugating tube, zygospore, and spore wall details. In part after Jao. Fig. 12.—*S. hungarica,* scalariform conjugation and zygospores from Sopron, Hungary. After Langer. Fig. 13.—*S. wabashensis,* gametangia and zygospores from Brownsville, Illinois. After Tiffany. Fig. 14.—*S. rugulosa,* gametangia and zygospores from Bologoe, Russia. After Ivanof. Fig. 15.—*S. visenda,* vegetative cell, gametangia, and zygospore from Columbus, Mississippi.

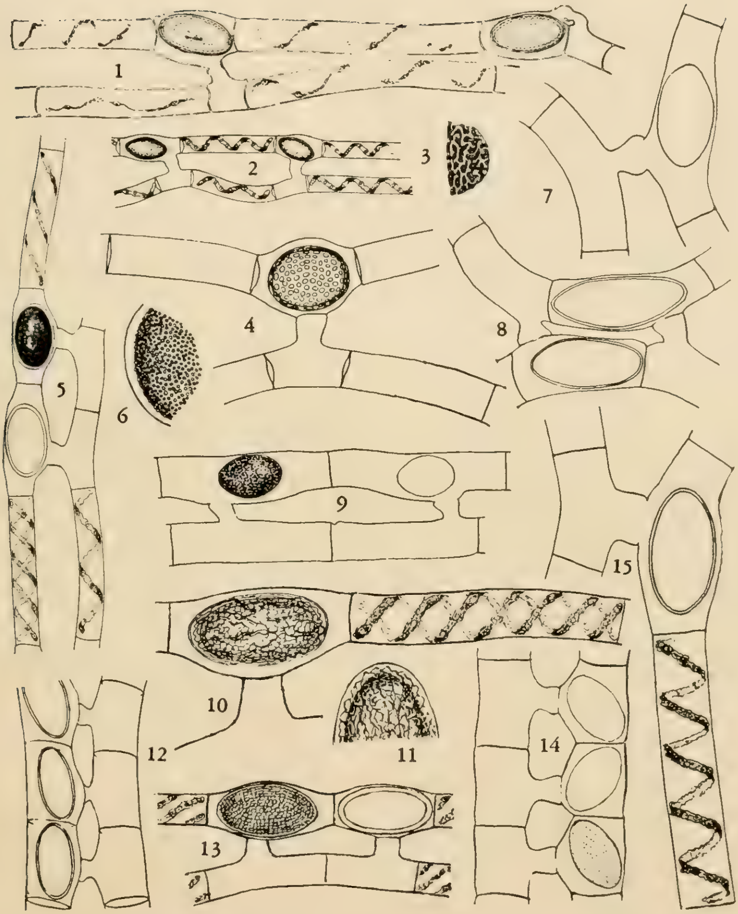
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PLATE XXXV

Spirogyra

Figs. 1–3.—*S. narcissiana,* vegetative cell with semireplicate end walls, aplanospores, and sporangia from Charleston, Illinois. Fig. 4.—*S. undulisepta,* zygospores and gametangia from Upper Punjab, India. Figs. 5–6.—*S. tenuissima,* zygospores and gametangia from China. After Jao. Figs. 7–8.—*S. inflata,* lateral and scalariform conjugation, and resulting zygospores from China. After Jao. Aplanospores from Illinois. Figs. 9–10.—*S. cylindrica,* lateral and scalariform conjugation with resulting zygospores from Austria. After Czurda. Fig. 11.—*S. pseudospreeiana,* gametangia and zygospore from Szechwan, China. After Jao. Figs. 12–13.—*S. pascheriana,* lateral and scalariform conjugation and resulting zygospores from Czechoslovakia. After Czurda. Fig. 14.—*S. weberi,* gametangia and zygospores from Germany. After Czurda. Figs. 15–16.—*S. semiornata,* lateral and scalariform conjugation, and resulting zygospores from China. After Jao. Fig. 17.—*S. hopeiensis,* gametangia and zygospore from North China. After Jao. Fig. 18.—*S. nyctigama,* vegetative cell, gametangia, and zygospores from Cape Colony, South Africa. Figs. 19–20.—*S. grevilleana,* lateral and scalariform conjugation from Bohemia. After Czurda.

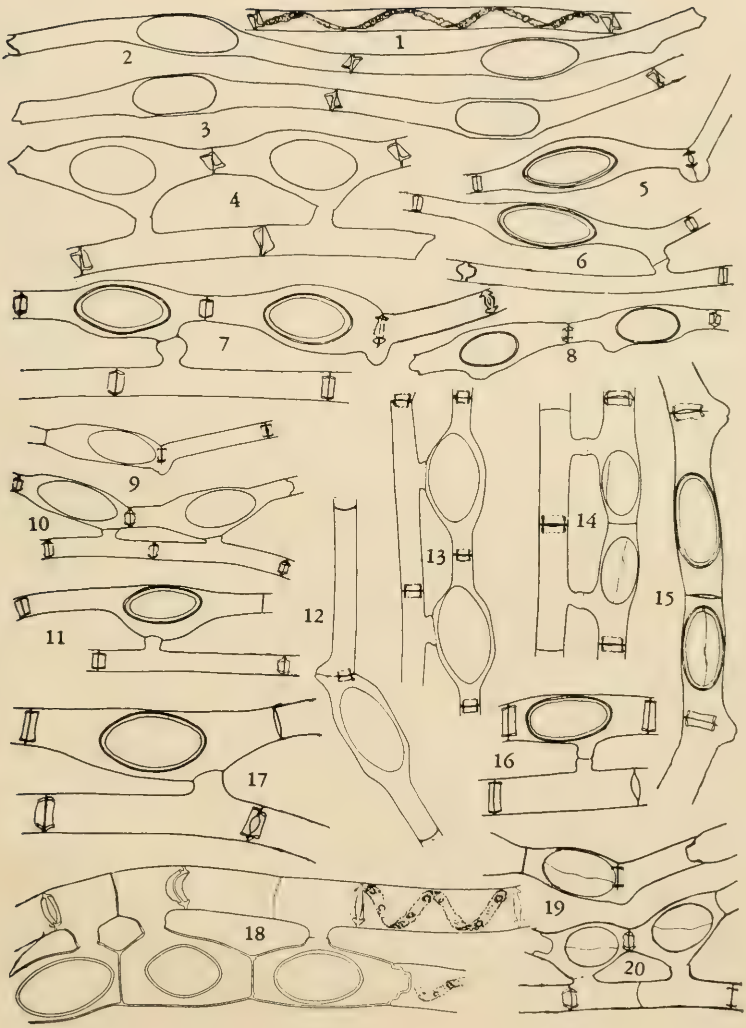
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PLATE XXXVI

Spirogyra

Fig. 1.—*S. chuniae,* zygospores and gametangia from China. After Jao. Figs. 2–4.—*S. incrassata,* lateral and scalariform conjugation and details of spore wall from Berlin. After Czurda. Fig. 5.—*S. foveolata,* zygospore and gametangia from Latvia. After Skuja. Fig. 6.—*S. discreta,* zygospore and gametangia from central Illinois. Fig. 7.—*S. kuusamoënsis,* gametangia and zygospores from Finland. After Hirn. Figs. 8–9.—*S. amplectens,* lateral conjugation and details of spore wall from China. After Skuja. Figs. 10–13.—*S. groenlandica,* vegetative cell, lateral and scalariform conjugation, zygospores, and an aplanospore from Boston, Massachusetts. Figs. 14–16.—*S. quadrata,* scalariform and lateral conjugation, and resulting zygospores from Szechwan, China, after Jao; the aplanospores were collected in Illinois. Figs. 17–18.—*S. dentireticulata,* zygospores and details of spore wall from China. After Jao. Figs. 19–20.—*S. fritschiana,* zygospores and gametangia from South Africa. After Fritsch and Rich. Fig. 21.—*S. goetzei,* zygospores and receptive gametangia from Lake Nyassa. After Schmidle.

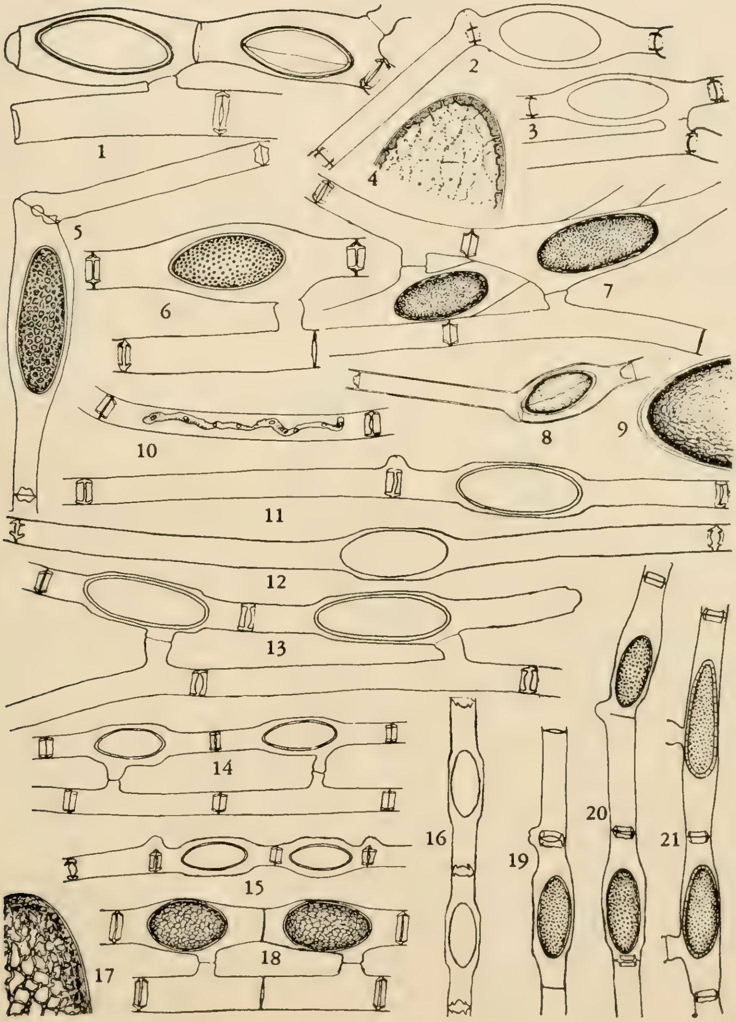
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PLATE XXXVII

Spirogyra

Fig. 1.—*S. lambertiana,* gametangia and zygospore from Maine. Figs. 2–3.—*S. microgranulata,* gametangia, zygospore, and wall pattern from China. After Jao. Figs. 4–6.—*S. spreeiana,* aplanospore, scalariform and lateral conjugation, and zygospores from Massachusetts. Fig. 7.—*S. tsingtaoensis,* gametangia and zygospores from China. After L. C. Li. Fig. 8.—*S. arta,* gametangia and zygospores from Szechwan, China. After Jao. Fig. 9.—*S. tumida,* gametangia, zygospores, and cylindrically distended sterile cells from Szechwan. After Jao. Fig. 10.—*S. articulata,* aplanospores and sporangia from Columbus, Mississippi. Figs. 11–12.—*S. regularis,* gametangia, zygospores, median spore wall markings. After Cedercreutz. Fig. 13.—*S. laxistrata,* gametangia and zygospore from Szechwan. After Jao. Fig. 14.—*S. croasdaleae,* gametangia and zygospores from Naushon Island, Massachusetts. After Blum. Fig. 15.—*S. denticulata,* aplanospore and part of sporangium from Massachusetts. After Blum. Fig. 16.—*S. lamellosa,* gametangia, conjugating tubes, and zygospore from Szechwan. After Jao. Figs. 17–18.—*S. venusta,* conjugating filaments, zygospore, and spore wall pattern from Szechwan. After Jao. Fig. 19.—*S. protecta,* conjugating filaments, zygospores, and optical section of spore wall.

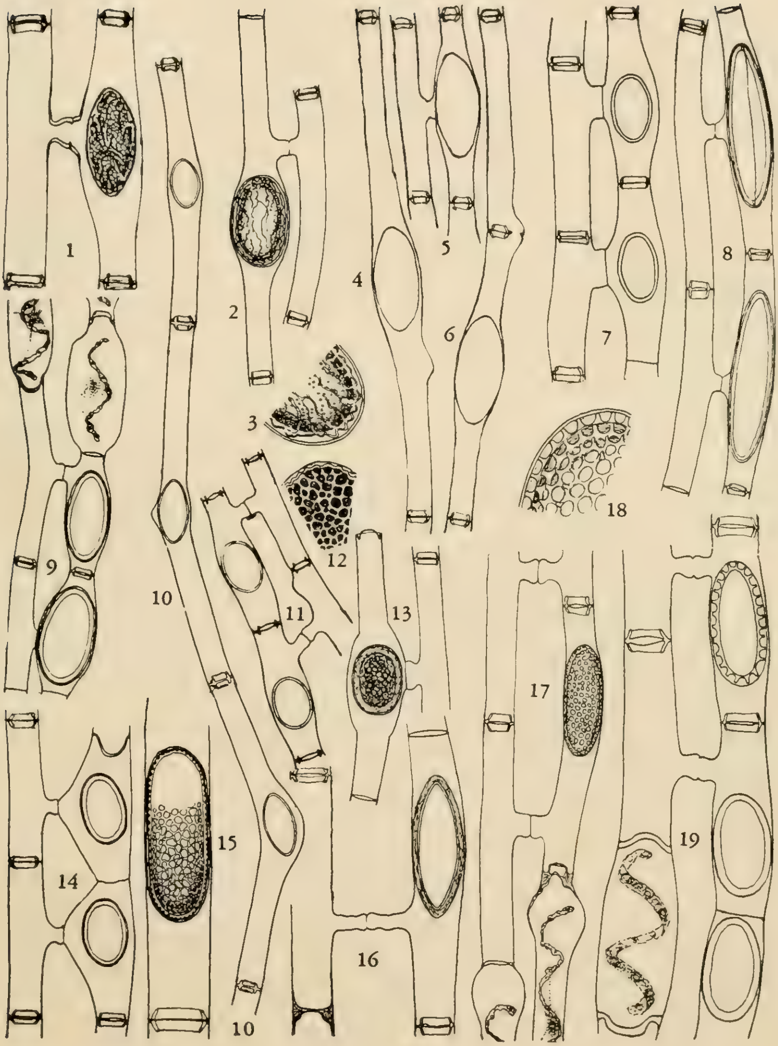
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PLATE XXXVIII

Spirogyra

Fig. 1.—*S. cleveana,* gametangia and zygospores from Szechwan, China. After Jao. Fig. 2.—*S. areolata,* gametangia and zygospore from central Illinois. Fig. 3.—*S. tolosana,* zygospores and gametangia from Indiana. Fig. 4.—*S. hassallii,* lateral conjugation and zygospore from Szechwan, China. After Jao. Figs. 5–6.—*S. hartigii,* scalariform and lateral conjugation, conjugating tubes, and zygospores. After Kützing. Fig. 7.—*S. proavita,* lateral conjugation and tube. After Langer. Figs. 8–9.—*S. gratiana,* straight conjugating filaments, scalariform and lateral conjugation, zygospores, and aplanospores. Fig. 10.—*S. transeauiana,* gametangia and zygospore from Szechwan, China. After Jao. Figs. 11–12.—*S. rectangularis,* scalariform and lateral conjugation with resulting zygospores from central Illinois. Fig. 13.—*S. fallax,* gametangia and zygospores from Bohemia. After Hansgirg. Figs. 14–15.—*S. wangi,* vegetative cell, gametangia, and zygospore from Hangchow, China. After Li. Figs. 16–17.—*S. acanthophora,* gametangia, zygospores, and details of spore wall from Latvia. After Skuja. Figs. 18–20.—*S. inconstans,* lateral and scalariform conjugation with resulting zygospores, and details of spore wall from Casey, Illinois. Note in Fig. 19 an almost complete absence of the reticulum on the spore wall. This depicts the extreme variation from Fig. 20.

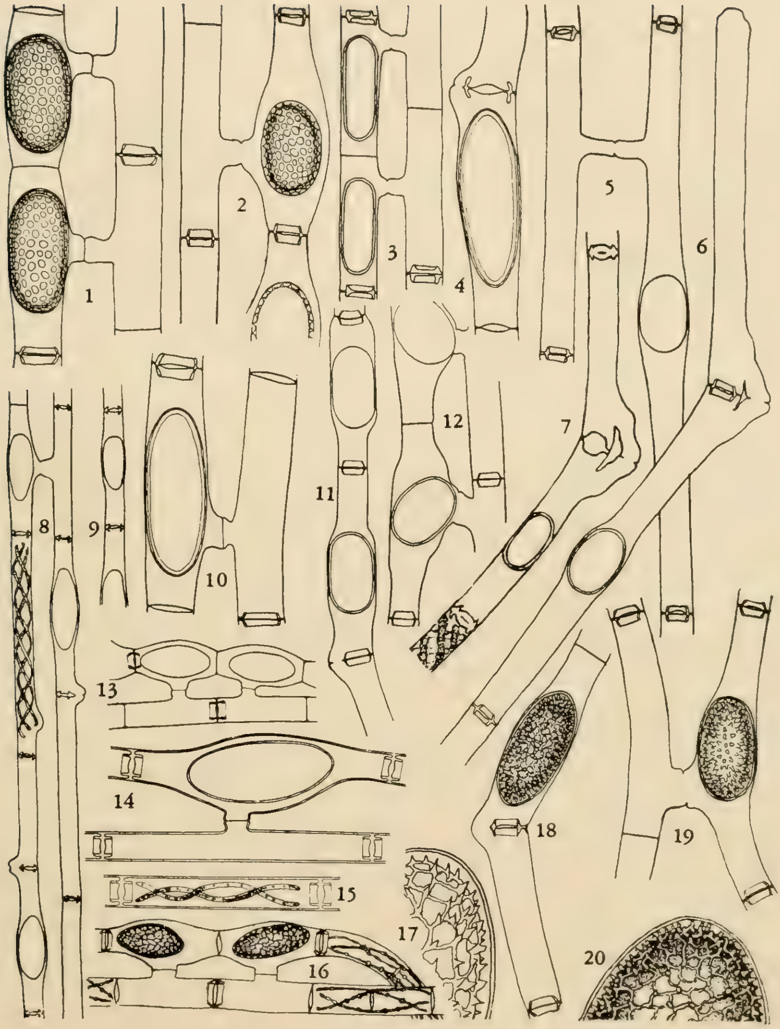
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PLATE XXXIX

Spirogyra

Figs. 1–3.—*S. borysthenica,* gametangia, zygospore, and optical sections of spore wall from Ukraine. After Kasanofsky and Smirnoff. Fig. 4.—*S. tetrapla,* vegetative cell, gametangia, and zygospores from central Illinois. Fig. 5.—*S. reticulata,* gametangia, and zygospore with outer median wall partly cut away exposing the reticulations on the inner median wall from Brazil. Fig. 6.—*S. crassivallicularis,* gametangia and zygospore from Massachusetts. After Jao. Figs. 7–8.—*S. granulata,* vegetative cell, receptive gametangium, and zygospore from Szechwan, China. After Jao. Fig. 9.—*S. pseudogranulata,* receptive gametangium and zygospore from Tong-Kau, China. After Ley. Figs. 10–11.—*S. quinquelaminata,* gametangia, zygospore, aplanospore, and details of spore wall, from Szechwan, China. After Jao. Fig. 12.—*S. jaoi,* gametangia and zygospore from Tong-Kau, China. After Ley. Fig. 13.—*S. chekiangensis,* gametangia and zygospore from Wenchow, China. After Jao. Figs. 14–16.—*S. crassispina,* scalariform and lateral conjugation, zygospores, conjugating tubes, and details of spore wall from Haimen, China. After Jao. Figs. 17–18.—*S. sphaerocarpa,* gametangia and zygospores, from Wenchow, China. After Jao. Fig. 19.—*S. subpellucida,* gametangia and zygospores from Wenchow. After Jao. Fig. 20.—*S. peipingensis,* gametangia, and zygospores from China. After Jao.

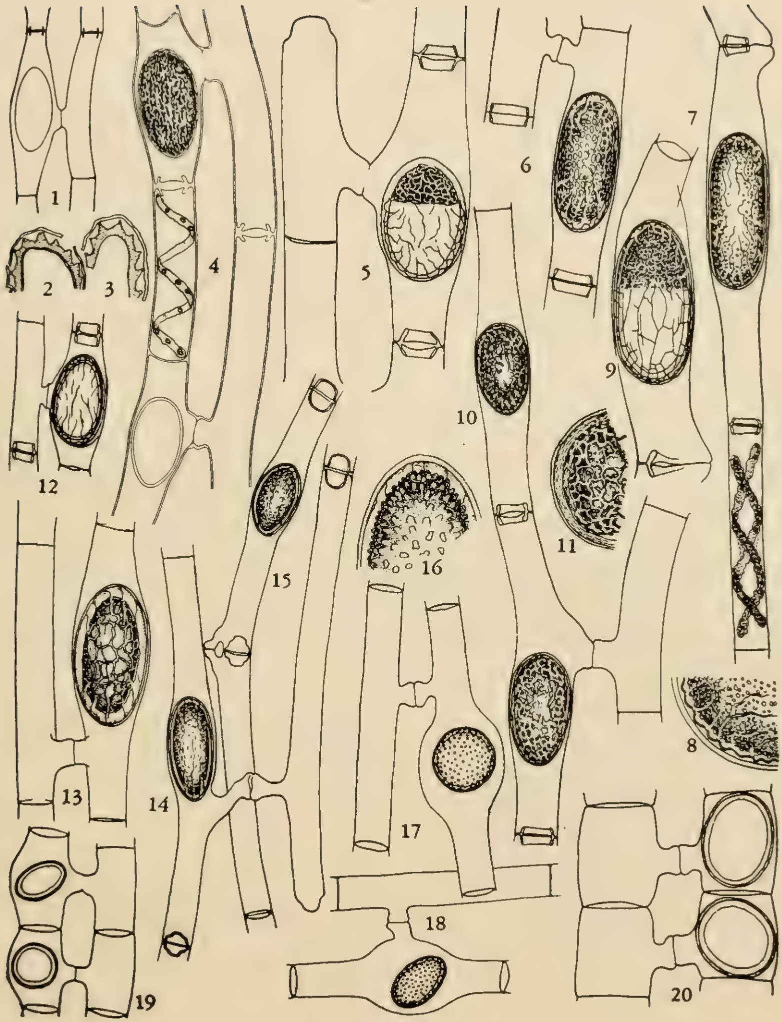
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PLATE XL

Sirogonium

Figs. 1–4.—*S. sticticum*, various types of conjugation and zygospores. The first three figures based on collection from Mayhew, Mississippi: (*a*) two pairs of equal gametangia, (*b*) conjugation between pairs of the larger subdivisions of the progametangia, (*c*) zygospore from three gametes 54μ x 144μ. Alternating pairs of conjugants between long and short gametangia, from India. After Randhawa. Fig. 5.—*S. megasporum*, gametangia and zygospore from Szechwan, China. After Jao. Fig. 6.—*S. pseudofloridanum*, gametangia and zygospore from Wisconsin. After Prescott. Fig. 7.—*S. ventersicum*, gametangia and zygospore from the Transvaal. Fig. 8.—*S. melanosporum*, gametangia and zygospore from India. After Randhawa. Fig. 9.—*S. indicum*, zygospore and gametangia from India. After Singh. Figs. 10–11.—*S. hui*, vegetative cell, zygospore, and details of spore wall from Kiangsi, China. After L. C. Li. Figs. 12–13.—*S. illinoiense*, early stage in conjugation with pectic ring around adhesion disc, mature zygospore, and subtending gametangia. On some spores the reticulum is less prominent than in this figure.

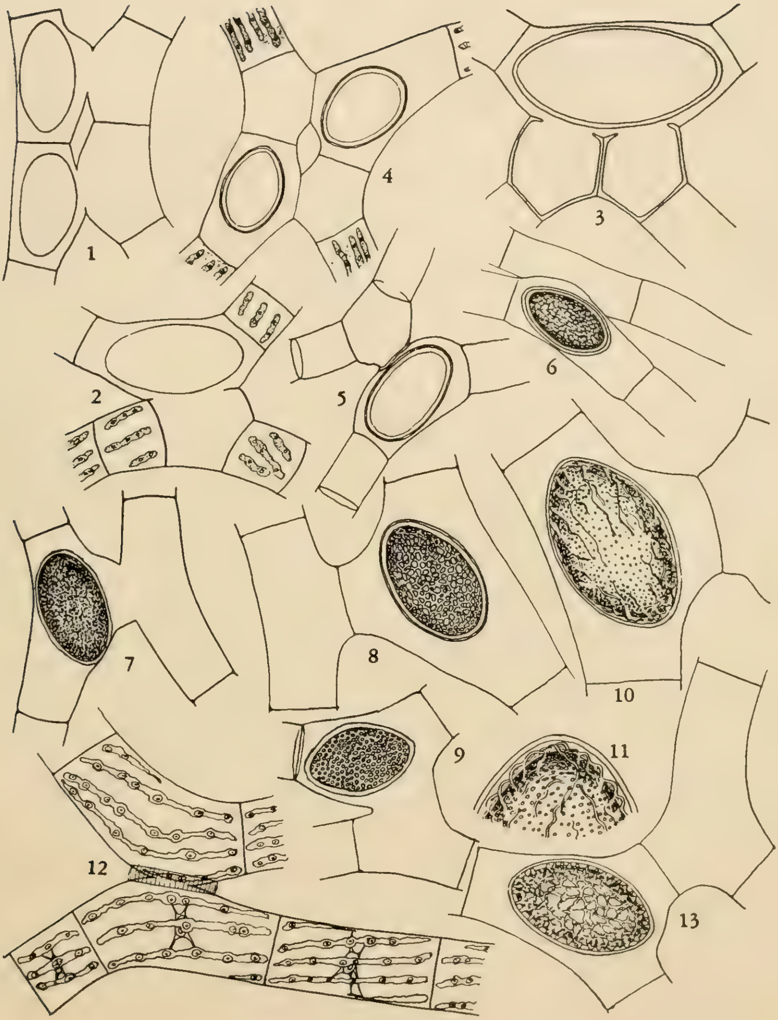
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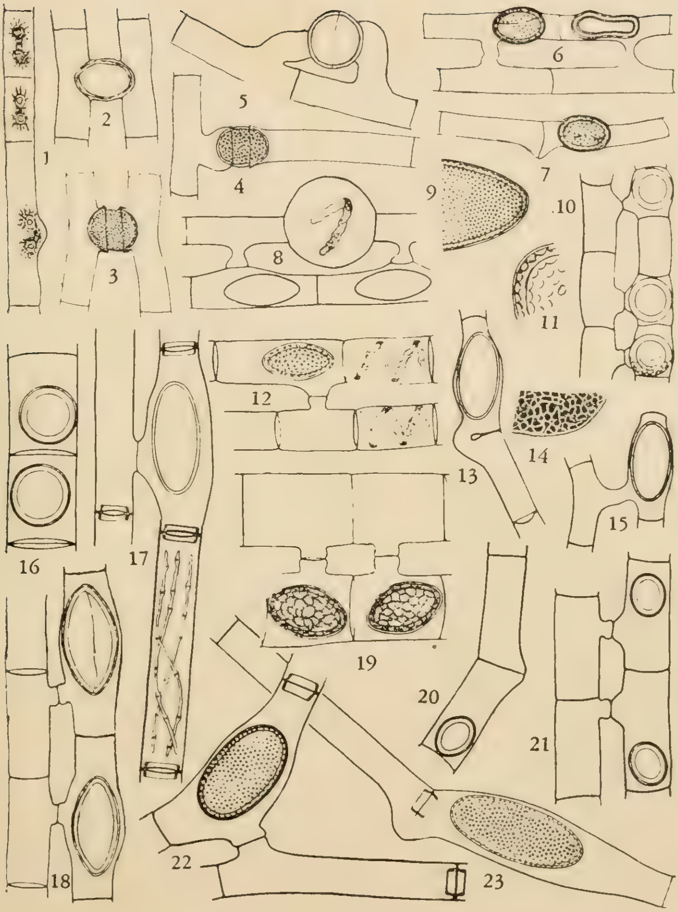
PLATE XLI

Zygogonium, Zygnema, and Spirogyra

Figs. 1–5.—*Zygogonium stephensiae*, vegetative cells, and gametangium (note relative length); immature and mature zygospores by scalariform conjugation; conjugation through end wall and mature spore; and the only instance of lateral conjugation seen in the abundant collections from Cape Colony. Figs. 6–7.—*Zygnema mucigenum*, scalariform and lateral conjugation, and mature spores from northern India. After Randhawa. Figs. 8–9. —*Spirogyra sibirica*, bullate sterile cell, scalariform conjugation, zygospores, and spore wall markings from Lake Zaisan region, Russia. After Skvortzof. Figs. 10–11.—*S. czurdae*, scalariform conjugation, zygospores, and spore markings from Kashmir, India. After Misra. Fig. 12.—*S. australensis*, vegetative cells and zygospore from Australia, Queensland. After Möbius. Figs. 13–15.—*S. pseudoreticulata*, lateral and scalariform conjugation, spore form, and details of spore markings. After Borge. Fig. 16.—*S. azygospora*, aplanospores, and sporangia from north India. After Singh. Fig. 17.—*S. insignis*, vegetative cell, gametangia, and zygospore. After Petit. Fig. 18.—*S. macrospora*, spores and gametangia from India. After Rao. Fig. 19.—*S. verrucosa*, gametangia and zygospores from central India. After Rao. Figs. 20–21.—*S. indica*, lateral and scalariform conjugation. After Rao. Figs. 22–23.—*S. marchica*, mature spores following scalariform and lateral conjugation. After Krieger.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